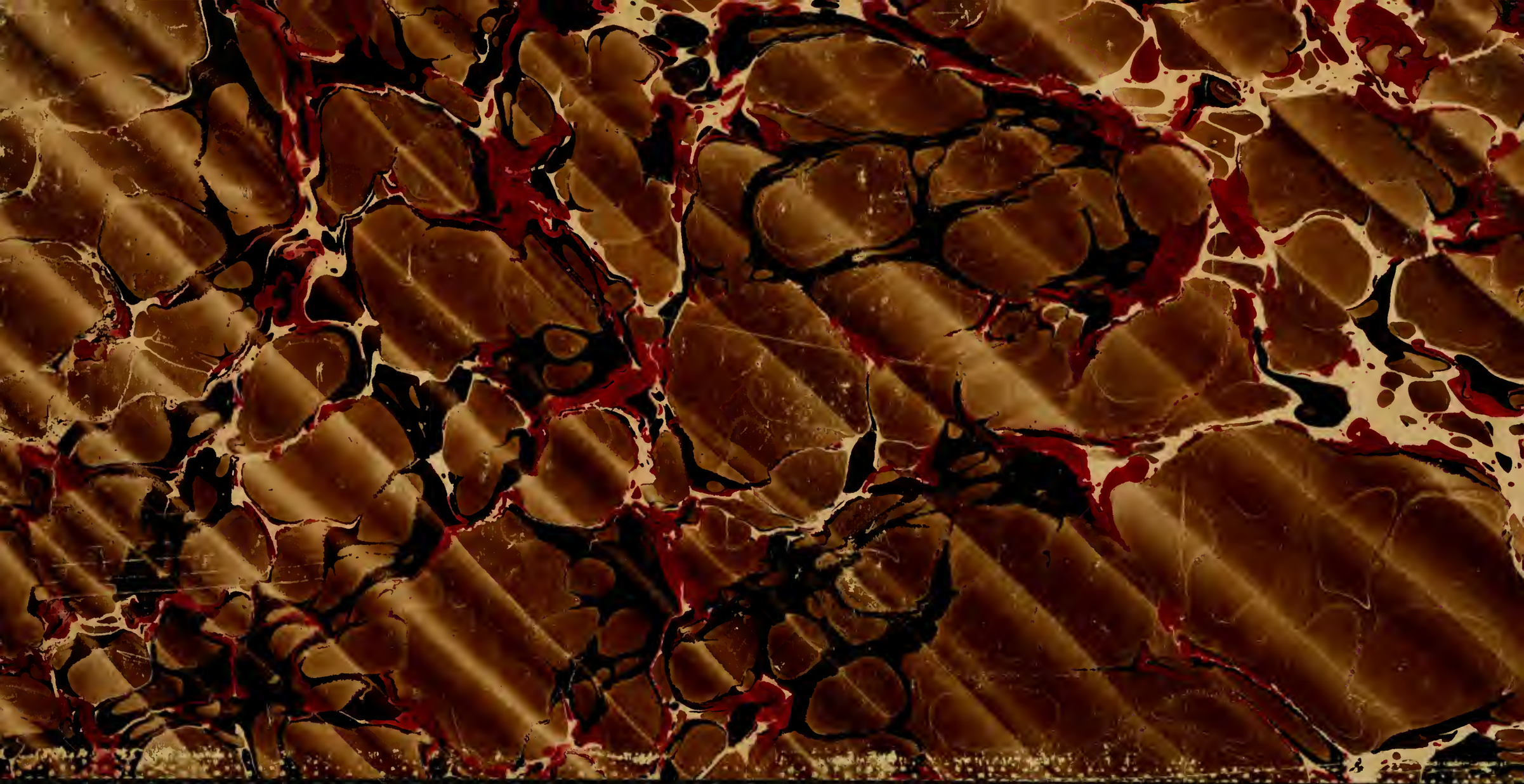

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WITH SEVEN PLATES.

EDITED BY

W. G. TIGHT, M. S.,

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

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Editorial Statement.

We desire to take this opportunity to extend our thanks to our numerous friends who have contributed to the museum of the Association and to its library; to those also who have contributed largely to the support of this publication; to Mr. E. S. Clark for a fine collection of plants and sea algae from Colorado and the Pacific coasts respectively; to Mr. J. Sanford for a collection of fishes from Lake Erie; to the University of Heidelburg, O., for a fine set of geological casts for the section of geology, and to numerous scientific societies and institutions, which, by their generous exchanges, have increased the value of our library.

It has been found necessary to postpone the publication of one of the articles intended for this volume until the close of the year, so that more time might be had for work, therefore this volume will appear in two parts.

Compliments of

W. G. TIGHT.

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SOME OBSERVATIONS ON THE CRUSHING EFFECTS OF THE GLACIAL ICE SHEET.

W. G. Tight.

It has been our privilege to devote considerable time of late to the study of the drift deposits of Licking county, including also a study of the effects of the continental glacier in modifying the topography. This region offers a very interesting field for work, as it is located just on the limiting line marking the probable advance of the ice cap. Part of the county being beyond the margin of the ice, and part evidently effected by it.

While the work is intensely interesting, it is at the same time exceedingly difficult, due to the subsequent action of the waters of the Champlain and Terrace epochs, thus working over and destroying the glacial deposits, and also on account of the character of the rocks acted upon, which are of a soft character and easily affected by disintegrating forces, so that the direct action of the ice, such as glaciation and scoring, is entirely lost. A more extended account of the results of the work done on this subject will appear in some subsequent volume of the Bulletin. At the present writing we desire to call attention to a few observations made at different points in some of the numerous quarries of the county on the character of the disintegration, and we offer them at this time, with the suggestions which they have aroused in our mind, not as representing any finished work, but more to direct attention to the subject and elicit any criticisms and suggestions which may be offered, and to learn whether anything has been done in this direction, and if so, where the desired literature concerning it may be obtained. Any information on this subject will be thankfully received. Our attention was first directed in this line while on a little geological excursion with our class. We were struck with the peculiar fractured appearance of the waste or surface rock above the solid stone employed by the quarrymen. The first quarry studied is located a mile north of Newark. Plate A is from a photograph showing about half of the quarry, which is located near the top of a high hill about a hundred feet above the creek bed. The

rock is the common freestone used so extensively for foundation work and building purposes. In Plate A can be seen the face of the solid rock which is worked, and a considerable portion of the broken material above it. Near the center of the illustration will be seen a large block of the harder portion of the rock, which has its corner broken by quite a number of curved fracture lines nearly parallel to each other and making almost a perfect truncation of the corner. These broken portions have slipped quite a little on the block in a downward direction, as seen by the fine lamination lines, thus indicating that the fracturing force was from above in a vertical line or but varying slightly from the vertical, and that it was not lateral, else the motion would have been in the other direction. Plate B represents a view of the rocks above the quarried rock in the same exposure, but on a little larger scale. Here it can be seen the rocks are fractured into all kinds of forms, having all sorts of curved and irregular faces, and it is impossible to trace any continuous jointing or stratification planes. However, in the individual fragments it is evident that the planes of stratification have been functional in determining form. On the top of this hill was found a number of erratics, and on the south side of the hill is a large deposit of glacial drift.

The next quarry illustrated, is located about one and a half miles south of Newark, and was chosen because it was about on an equal elevation with the first, and the exposure can be identified as being of exactly the same geological horizon, by a thin layer of coarse grained sandstone which is present in both. If, however, we study the rocks in this quarry, as will be seen in Plates C and D, which are taken from different parts of the same exposure, we will find that they are broken largely in but two directions, one along the planes of stratification, which can be followed through the whole quarry, no matter how near we approach the surface, the other almost at right angles to the first, vertical or nearly so, and corresponding in direction to the joint planes of the underlying harder rock. It will be seen also in Plate D especially, that no matter how close the rocks may come to the surface at the side of the hill there is no apparent breaking over in concoidal fractures. We also notice that the disintegration depends almost entirely upon the varying composition of the individual strata. No erratics were found on top of this hill, although they were quite abundant in the proximate valley, and drift material is also abundant at the bases of the neighboring hills. Many

other minor points might be mentioned which bear on the subject, but as this is not intended as an exhaustive treatise, they will be omitted for subsequent consideration. The facts presented indicate that the rocks of one quarry, those represented by Plates A and B, have been subjected to a tremendous pressure, and the others have not, or at least not to such an extent. That the pressure in the first case was from a superposed burden and not a lateral force. And it is evident that the burden has been subsequently removed. We believe that the first named quarry was covered by the ice sheet, and that the second quarry considered was not so covered, and would suggest it as a possible means of determining the extent of the ice front in regions where the country rock is easily fractured and presented in erosion hills.

As far as our observations on other exposures have extended we think they sustain us in our views, those within the glacial region showing evident marks of fracture by superposed burden and those beyond the recognized limits showing no such evidence. From the curved forms of the fracture spoken of in Plate A, and shown in many other instances in a more or less decided manner, it has been suggested that data might be derived by which the thickness of the ice, or at least the amount of the breaking force might be determined. Apparatus is now under construction for studying the resistance of blocks of the rock of different dimensions to a crushing force, and the forms of the fractures produced. There are many difficulties to be overcome and many modifying influences, but it forms at least a very inviting field for investigation. The illustrations are all from photographs taken and prepared by the author.

VIEW OF A PORTION OF HORN'S HILL QUARRY, NORTH NEWARK, O.

PHOTO BY W. G. TIGHT.

VIEW OF A PORTION OF HORN'S HILL QUARRY, NORTH NEWARK, O.

PHOTO BY W. G. TIGHT.

VIEW OF A PORTION OF THE SOUTH QUARRY, NEWARK, O.

PHOTO BY W. G. TIGHT.

PHOTO BY W. G. TIGHT.

VIEW OF A PORTION OF THE SOUTH QUARRY, NEWARK, O.

BIOLOGICAL NOTES UPON FIBER, GEOMYS AND ERETHYZON.

By C. L. and C. Judson Herrick.

It has been considered appropriate to prefix to the account by one of us of certain neurological peculiarities of the above mentioned rodents, a brief statement respecting their habits and some points in their anatomy more or less directly bearing upon their nervous structures. The three groups are widely separated, and yet have a number of curious similarities, or rather agree in certain differences from other rodents in a way which may serve to justify the comparison as well as the contrasting of the types selected.

The Muskrat, *Fiber zibethicus*, is sufficiently well-known to every one, and yet perhaps few are aware of the extent to which the animal adapts itself to the varying conditions of its environment. One who casually learned to know the water rat in one of our western states might pass many years in Ohio without recognizing the fact that the same animal abounds in Ohio, and under the changed conditions here prevailing adopts an almost wholly different method of life. It would be more accurate to say that in the cold North-west, with its luxus of small lakes and marshes, the monotonous career of the animal expands in conformity with the greater variety of aquatic stations.

The muskrat is a truly Arvicoline rodent, that is, its affinities are with the field mice rather than with the jumping mice (*Hesperomys*) or oriental rats and mice (*Mus*). Though, at first sight, very different from *Arvicola*, the chief differences in *Fiber* are such as are obviously adapted to aquatic habit. The long, laterally flattened, scaly and naked tail, small ears, obliquely set and fringed hind feet with webbed toes are all modifications induced by accommodation to acquatic habit. The dark brown fur is long, with a liberal admixture of long, stiff, glossy hairs of a darker color than the rest. The color and texture varies with the season and in early summer rats may be found with a curiously tufted or mottled pelage. There are six mammæ and strongly developed perineal glands which are responsible for the peculiar musky odor implied by the name. The secretion is

often used by trappers for the more expensive castoreum in preparing "scent" used in baiting traps.

As, already indicated, the habits of the muskrat are subject to considerable variation. Its usual home is a long burrow opening beneath the surface of the water and passing many yards into the bank, terminating in a cosy nest beneath the protecting roots of a tree. It is here that young are reared and from these burrows the entire family may be seen emerging at twilight to engage in swimming races, games of tag, and sportive contests upon the surface of the stream. The head and rudder-like tail alone project above the surface and the long V-like diverging ripples which are created by the rapid swimmer soon span the entire stream and stand out in bold relief as they catch the sky tints at sun set. In regions not frequented by man or sufficiently protected by trees long run-ways may be traced from these burrows into neighboring meadows or wheat-fields. The family is large and the appetite is extensive if not critical. Almost anything of a vegetable nature will be tolerated but the corm-like roots of rushes and the rhizomes of the water-lily as well as flag roots are relished. The frantic and grotesque haste with which the rat when disturbed rushes down the run way toward the water, oblivious to any obstacle, is very amusing and sometimes startling and may have given rise to the stories of fierce on-slaughts upon man. Young man-afraid-of-his-shadow might readily consider himself beset as the excited rat comes crashing down his path regardless of everything but his destination. Nevertheless there seems to be considerable evidence that old "rogue" rats are decidedly irascible, and a worried mother rat may over-step the bounds of etiquette in defence of her young. The burrowing habits of the rat associate him with the cray-fish and other enemies of canals and dams. Even in the vicinity of a large city like Cincinnati large numbers are annually taken in the canal-banks for their skins, which, when in prime condition, bring 15 to 18 cents

The comparatively simple domicile above described is adequate for the southern states and flowing waters but in Wisconsin and Minnesota the conditions are very different. Nearly every quarter section has its small lake or pond and these pools are shallow and mostly filled with weeds. Here the muskrat finds congeneal resorts Even in the bleak prairies the sloughs and ponds fairly swarm with these furry denizens. Here the intense cold of winter freezes all standing water to a depth of over four feet so that the openings of the summer homes

of the rat are sealed for four or five months and he is forced to construct a building suited to the seemingly infelicitous and conflicting conditions. The house must extend above water to admit air; it must be deeply buried from the cold; it must connect with the water; it must contain food; the food should be growing or fresh; the house should afford protection from enemies and escape when attacked.

The solution of these problems might tax the ingenuity of the ablest mind, yet nature, by the use of the simplest materials under the guidance of natural selection, has solved every one. Let us watch the process and, I doubt not, learn a lesson of skill and patience. The situation is a shallow pool which is destined to freeze nearly solid. It is grown up with rushes and *Nuphar* or spatter dock, two plants which play an important part in the domestic economy of this animal, supplying him at once with food and building materials.

In the placid days of early autumn a pair of muskrats may be seen diving to the bottom and tugging and biting at the roots of the rush. After tearing them off, the rat collects four or five of the rushes, say four feet long, and swims with them to a spot selected over the deepest part of the pool. Here they are arranged in parallel order and carefully straightened. Then another mouthful is brought and placed across the first at right angles. The angles are bisected by other clusters until a circular raft is formed sufficiently strong to support the weight of the animal. Now the colony of rats sets at work in earnest. And all day long one or more rats may be seen on the platform apparently eating rushes. Closer inspection shows that they are biting rushes into short lengths to form the "filling" of the structure. The accummulation increases and its weight causes the raft to sink and a new series of long rushes is added. Thus repeatedly until sufficient material has been accummulated to rest on the bottom of the pond. All the previous weeks the rats seemed to make little progress, as the material sank as fast as lifted much above the surface. During the early stages a strong wind may ruin the work of weeks but the rats are never discouraged.

So far only vegetable matter has entered into the composition of the hut, but as soon as it begins to rise permanently above the water there is a change of method and the whole space about the lodge is cleared of vegetation. The rats dive to the bottom and pull up the rushes and water-lillies by the roots and build them into the structure with large masses of earth adhering. The bottom is deepened and

thus the danger of freezing solid is obviated. The earth is used in plastering the outside of the hut, though this is not systematically done. A curious habit we have occasionally observed is the thatching of the hut with the large water-lily leaves so overlapping and cemented with mud as to form an impervious roof. By this time the ice is beginning to form and the hut has settled as much as it will, being buoyed up by the ice. The rats now burrow into the house from near the bottom forming a passage in the form of a letter U inverted, the uppermost part being above the water level and here a small chamber is excavated. Run-ways are excavated beneath the ice to various parts of the pond. In the long excursions undertaken beneath the ice the rats are said to ascend to the ice and exhaust the lungs, permitting the expired air to absorb oxygen and then reinspire it. This we have never been able to observe. The roots of Nuphar are built into the house or are stored conveniently near for winter use. The great mass of vegetable matter soon begins to "heat" generating warmth enough not only to add to the comfort of the occupants of this curious home but to cause new sprouts to spring from the roots. The chamber is enlarged during the winter and the part removed serves to supply food in case of outside famine. The outer layer of mud freezes solid and forms an adequate defense against the wolves which might otherwise wage a war of extermination. There seems to be a certain reciprocity between the occupants of adjacent lodges, although the rats are jealous by nature and have not the communistic characters of the beaver, though no whit inferior to them as architects.

As to the statement commonly believed by woodcraftsmen in the West that the muskrat prearranges his hut in view of the length and severity of the coming winter we can offer nothing definitely. There is, however, a wide variation in respect to the size and structure of the huts and a general correspondence though by no means a universal one, between the huts built during a given season. An average hut is 6x10 feet in diameter at the water's edge and the size of the chamber varies from 18 inches to two feet.

The Pocket Gopher or Pouched Rat, *Geomys bursarius*, although abundant west of the Mississippi, is probably unfamiliar to most non-professional observers. This animal is nevertheless the representative of one of the most interesting and distinctive of North American mammals.

Being practically subterranean they are little exposed to interruption and from their habits little likely to spread rapidly, they multiply in favorable localities to an incredible extent and miles of meadow land are honey-combed by their burrows. Their natural habitat is moist sandy bottom or prairie land where vegetation is succulent and the soil yielding. A large river naturally forms an almost insuperable barrier to their distribution. The centre for the whole group is in the upper Missouri region and various species extend northward into the Saskatchewan region and southward into Mexico. The group does not extend much east of the Mississippi except in the Gulf States. The existing genera are closely related. In New England and the Middle States they are entirely absent. There are obvious resemblances in the various members of the *Geomyidæ* to the field mice *Arvicolinæ* especially in important cranial characters while a more superficial resemblance, due chiefly to the presence of cheek pouches, allies them with the pouched mice or *Saccomyidæ*. There are many points of agreement also with the African mole rats (*Georychidæ*) which they more nearly resemble in their habits.

As just indicated, these low-bodied, rat-like, but densely furred animals are chiefly remarkable for the large fur-lined pockets extending from the shoulder to the sides of the mouth but opening entirely outside the buccal cavity. These pouches have special muscles and are used in carrying food which, in all the species, is stored in subterranean graneries.

The fur is dense and very soft and mole-like. The under fur is plumbeous and very fine. Superficially the color is a subdued but rich brown with a purplish or reddish reflection and a glossy brilliancy during life which is lost in the prepared skin. The head and middle of the back are darker brown. Beneath, the colors are much lighter becoming whitish on the feet, tail and lower lip. There is also a light spot on the nose and below the small muffle. The vibrissæ are thin and pale. The female is lighter. A peculiar phase of coloration not known to correspond to any seasonal or physiological condition, occurs in animals which are dark gray, almost black, and uniform throughout. In old individuals there is a considerable admixture of white hairs especially upon the head. In summer the feet and tail become nearly naked. In form the pocket gopher differs form the rat-like rodents in the large relative size of the head and shoulders as well as the fore feet. The body tapers rapidly backward and the hind

limbs are very small. The tail is short and tapering and nearly destitute of fur. The enormous fore feet have a greatly expanded palm with special cartilaginous support but these members are not laterally rotated and displaced, as in the moles. The lower surface of the palm has a decided ridge which is reenforced by stiff bristles, making a serviceable scraper as the two are pushed in front of the animal.

The habits being entirely subterranean with the exception of rare nocturnal forays, our acquaintance with the animal must necessarily be formed under unfavorable conditions. It is little wonder that when dragged ruthlessly from his home a prisoner in the jaws of a trap, the recluse-like animal produces an unfavorable impression. When thus brought into the blinding glare of the day light he throws himself back upon his haunches, elevates his head, and, half in fury, half in pain, gnashes his teeth and utters the aspirated sigh-like spit which is the only note of offense. Blinded by the light, he turns toward every sound and appears quite demented. But in the seclusion of his burrow or when once on friendly terms with his captor, he appears a very different creature. Perhaps we are the only persons who have had the opportunity to study the interesting habits of the Geomys in captivity. After a short time he becomes perfectly tame and an engaging pet. When first secured he ate sparingly of potato but evinced decided preference for leaves and rhizomes of red clover, seizing them in one fore paw, which was used as a pair of forceps by bringing the long claws in opposition to the callosity of the palm, and feeding himself gracefully. While eating he assumed a semi-erect attitude and arched the back much as the muskrat does. In eating a clover plant he always pursued the same methed, beginning at one extremity and "feeding it into" the mouth rapidly and uniformly using now one fore paw, now the other. After the keen edge of the appetite was removed the animal began at once to stow food into his pockets, in doing which he reversed his former position and seemed to all but stand on his head, cramming in the leaves and roots with much celerity. The play of the jaws is ordinarily like that of a rat, but at times, when a large root was encountered the jaws were set in rapid motion so that the clicks made by the teeth blended in one uniform clatter. A similar habit has been noticed in several rodents, especially the porcupine. The only truly vocal sound was a sharp squeak if the hissing note of rage be excepted. Upon the smooth surface of the floor the motions seemed embarrassed and awkward. A small twine stretched

on the floor served to stop his course until he divided it with the teeth rather than step over it.

When placed in a vessel of fresh earth the Geomys seemed almost distraught. The smell of fresh soil acted as a powerful stimulent and the animal careened about before falling to violent digging which he carried on literally tooth and nail, biting the clods, rooting violently, and throwing back the earth with the feet. This, however, was but play, and it was only when given larger quarters that he began the excavation of a burrow in real earnest. The position in digging is with the hind feet well forward and the back strongly arched. The earth is thrown back with the fore paws, and, as it accumulates under the animal, the latter launches a vigorous kick with both hind feet in the most ludicrously earnest manner. After a considerable pile is thus formed behind the animal, he turns about and approximating the callosities of the two fore feet in front and with the claws well up, he pushes the mass before him by the action of the hind limbs until it piles up in front of him, and he looks like a diminutive earth scraper. It is in this way that the earth is brought to the surface and not in the pockets as often stated. The whole process is accomplished in the most brisk and business like manner possible. Thus, in the habits of the animal we have the explanation of an osteological peculiarity of the wrist. There is a strongly developed bone (the falciforme) not found in many mammals which serves to support the callosity which in this case, as we have seen, serves both as a scraper and an aid in prehension. The most noticeable fault of the gopher is his gluttony. The amount he eats is alarming. Our pet seated himself calmly upon the knee and disposes of one grass stalk after another most vivaciously, eagerly seeking for more. Bread was especially desired and with a shrewd eye for the future the beggar would fill both pockets and when appetite and both pockets were filled he would empty the latter in a corner of his den and promptly return for more.

When given the liberty of the room, he set off in a curious canter but usually returned to be placed in the box, where he constructed a new nest every day. In the darkest portion he formed a nest of dry grass where the midday sleep was enjoyed. This siesta is very profound so that one could frequently remove him from the box before he awaked, which he did with a start and appeared to require some time to get his bearings.

In suitable localities one may trace the progressive extension of the burrow by the small hillocks of earth thrown up, often extending in an irregular line for many rods in a meadow. The digging is chiefly confined to the early summer and autumn, or after a long rain. Dry earth is difficult to manipulate and during drought the favorite food of the gopher is not to be secured. The hillocks resemble those of a mole but are much larger The burrows are of two sorts, permanent run-ways and explorative or temporary burrows. The latter are near the surface and are closed off from the permanent burrow when completed. When such a burrow is made in a potato field it can be traced with the utmost regularity from hill to hill and the tubers are systematically removed and stored in large deep cellars. The amount which one family will carry off in a few days is all but incredible. The natural food consists of grass roots, especially the tender shoots of the red clover, and like plants. A curious provision against winter needs was frequently observed. The main run-way was provided with blind alleys at intervals, each of which was somewhat expanded at the end. Here a store of grass roots is accummulated in quantities varying from a pint to nearly half a peck. The amount seems to be intentionally limited so that the slight heating shall stimulate the roots to fresh growth, thus providing fresh supplies for the winter. Larger chambers are constructed for the tubers of Helianthus, etc.

It is probable that the animal does not drink. Current stories as to the digging of subterranean wells and the like being, so far as we could learn, fabrications. There is no evidence of hibernation though in the nature of the case it cannot be disproven. The female appears to perform most of the work of digging.

The gophers may be trapped by one familiar with their habits. When a fresh mound is found this should be opened so that direct day light falls into the burrow. Then a second opening is made along the trend of the passage about eighteen inches from the first. The opening is carried a few inches below the level of the run-way and in it a small steel trap is placed. The trap is carefully covered with light earth to the level with the run way and the light completely excluded from the second opening. The success of the plan depends upon the dislike of the gopher for light. He at once brings a fresh supply of earth to stop up the opening and being blinded by the light does not

observe the second excavation. If the latter presents any irregularity, however, he immediately deposits the load there and barricades the burrow at that point.

The Porcupine (*Erethizon dorsatus, L.*) is familiar to everyone from pictures and yet few have had the opportunity to observe it in its home in the pine forests of the north. In fact there is little to attract or awaken interest except for the peculiar quill like modification of the hair. Although a true rodent its gait and habits strangely suggest the hog and earn for it its popular pseudonym. Its distribution is largely coincident with that of the northern pine forests, though it delights to feed in the lush vegetation of the meadows bordering the quiet rivers.

A visit to the pineries of north-western Wisconsin by one of us during midsummer of 1890 afforded especially good opportunities for the study of their habits. Here settlers are few and the beasts of the forest still hold almost undisputed dominion. The porcupines, however, seem to prefer the settlement, being apparently very social in their tendencies and almost devoid of fear. The settlers detest them for their predacious habits and general ubiquity. They often nest under the floors of the cabins, particularly if deserted, and after the settlers have turned in, they enter very unceremoniously, prying into every thing, filling the clothes of the men with quills and working woe with the pork and beans designed for breakfast. In one case a crew of lumbermen was summarily awakened to find that an inquisitive "porky" had crawled into bed with them. It is needless to add that the previous occupants did not stop to parley, but left him in undisputed possession. For these reasons the settlers usually dispatch them with clubs or axes, whenever they find them. This method is preferable to shooting, for, on the one hand, they are very fat and sluggish animals and rarely attempt to escape, and, on the other hand, their reptilian tenacity to life makes the effect of a rifle ball very uncertain.

An animal riddled with rifle balls will sometimes climb to the top of a tall tree to expire in its crest. Their perfect protection from their enemies of the forest is to be their ultimate destruction, for it has favored those structural and mental peculiarities which make them an easy prey to mankind. As the settlers take possession of their native woods, it is perfectly obvious that the porcupines are a doomed race, soon to be found, like the American Bison, only in parks and zoological gardens.

In the vicinity of the settlements they seem strictly nocturnal, coming out of their burrows at dusk and retiring into them again at daybreak. But deeper in the forest they may be seen sporting about their burrows or swinging in the tree-tops above them at almost any time of day. Though very awkward on the ground, they are excellent climbers and will mount the straightest pine trunk with the greatest agility, with, however, a ludicrous appearance of clumsiness and a clatter which can always be recognized. Members of the same litter (usually not more than two) appear to keep together during the first season, even after maturity, and may frequently be encountered after nightfall picking their way through the brush in single file with that shambling gait and peculiar squeaking cry which at once remind one of a litter of half-grown pigs, and which wins for them the common appellation of "quill pigs."

Later in the year we had an encounter with one under rather unusual circumstances. Quietly paddling in a birch canoe provided with a flaming torch in the bow, we were watching for the luminous eyes of deer, which in the brightly illuminated area, stood quaking at the sudden apparition, or stampeded and rushed up and down piping a warning note to the remainder of the herd.

Our attention was attracted by a peculiar clattering sound—evidently the teeth of some animal in rapid motion, but louder and more rapid than anything we had ever heard. The source of the sound we were for a time unable to make out, but it was soon betrayed by the sound of heavy feet and some clumsy animal approached the swampy shore and began to feed upon the new growth of arrow-head leaf (*Sagittaria*) with the same noisy clatter. A charge of heavy shot brought the animal to the water's edge where, to our surprise, it immediately took to the water and swam toward us in a decidedly vindictive mood. Twice we fired buck shot into it at yard range before it ceased its attempts to swamp us. The stomach of this animal contained nothing but the finely divided shoots of sagittaria. On the same night a second individual was shot which clambered to the top of a tall tree. It must not be assumed, however, that the porcupine is necessarily nocturnal. In the sunny afternoon they may be seen feeding in the meadows, using their four-clawed hands with awkward cleverness in bringing grass tufts within reach of the mouth. If alarmed they clamber under the overhanging bank, and, drawing the

body together with quills bristling, they lie in fancied security. Nor are they far wrong so far as other animals than man are concerned.

The porcupine offers great inducements to wild cat or panther, which, nevertheless, never tempt these animals to attack the quill pig except in greatest extremity. We have received specimens of *Lynx rufus* with the head filled with the quills, some of them even entering the orbit. Even the panther is sometimes destroyed by these barbed weapons.

While there is no truth in the current belief that the porcupine discharges its quills voluntarily, yet it appears that by lashing its tail it may lodge some of the barbs in the skin of its enemy. Once fastened, these quills strike inward with great pertinacity and every movement serves to propel them onward.

Although preferring succulent vegetation or the green inner bark of poplars, etc., the porcupine is, upon occasion, omniverous.

The taste of salt is greatly relished and pork skins and barrels in which brine has been kept are greedily eaten, even the slight saline taste imparted by the hands to oars and ax-helves attracts them, and the implements of the lumbermen often suffer from their teeth. The Indians regard them in their turn as delicate food and prize it highly, as we had occasion to learn in barter for a specimen.

The porcupine is a good swimmer, voluntarily crossing large rivers. Being so fat the body is relatively light and protrudes greatly above water.

It is stated by careful observers that during the very coldest weather these animals sometimes pass days and weeks swinging pendent in the tree tops, literally in a state of suspended animation.

The one or two young are brought forth in May and are proportionally larger than in any other rodent. Dr. Merriam mentions one which weighed over one and one-fourth pounds prior to birth, being 11¼ inches long. A full grown male measures three feet in total length.

STUDIES IN THE TOPOGRAPHY OF THE RODENT BRAIN: ERETHIZON DORSATUS AND GEOMYS BURSARIUS.

By C. Judson Herrick.

The design of the present paper is to contribute further details in the direction indicated by the article on the Central Nervous System of Rodents in Volume V of this Bulletin. The types chosen for these studies were selected partly because they represent groups very different from Arctomys monax, the type there discussed, partly because they seem to be aberrant members of the rodent stock and present striking peculiarities both in habits and in general structure. Erethizon dorsatus is our only North American representative of the Hystricidæ. In spite of important structural differences, it is very similar to the European genus Hystrix, in which it was placed by Linnæus, and it seems to be connected with the European porcupines by geological remains.* Geomys bursarious, the "pocket gopher" of the West, is widely separated from the other Myomorpha by its fossorial and nocturnal habit and the peculiarities of structure resulting from it. Points of more general interest with reference to these eccentric forms are discussed elsewhere in this number.

No attempt has been made to consult all the literature bearing on this subject. Works which have been especially helpful are noticed in connection with their respective topics.†

*See J. A. Allen in "Monographs of North American Rodentia," Washington, 1877, p. 397.

†The following have been consulted for the general topography:

Krause, W., "Die Anatomie des Kaninchens," Leipzig, 1868.

Steida, L., "Studien ueber das Centrale Nervensystem der Voegel and Saeugethiere." Zeits. f. wiss. Zoologie, Bd. XIX.

Steida, L., "Studien ueber das Centrale Nervensystem der Wiebelthiere." Zeits. f. wiss. Zoologie, Bd. XX.

The brains were hardened for 24 hours in weak chrome-acetic acid, then passed gradually from 50 per cent. to commercial alcohol, as usual. All sections were stained by hand with Grenacher's hæmatoxylin. The tracts were brought out better by using the concentrated stain, making it quite intense. For the minute histology, however, much better results were secured by diluting the stain from four to six times its volume and applying it long enough to give only a faint color.

EXTERNAL FORM AND MEASUREMENTS.

Erethizon dorsatus. This brain differs greatly in general appearance from the usual rodent type. The narrow anterior extremity, passing into the olfactories, the compression at the Sylvian region, and the widely diverging flocculi, which give to the rodent brain its characteristic appearance are not obvious here. Judging from Owen's figures,* there is a resemblance in these points to the beaver. The porcupine brain is much wider in proportion to the length of the hemisphere, but both are well filled out in front. The European porcupine, Hystrix crista, has these characteristics much more pronounced. If Owen's figures† be correct, the cerebrum is considerably wider in proportion to its length than that of Erethizon. The common American muskrat, Fiber zibethicus, also has a cerebrum which much resembles that of Erethizon.

The Rhinencephalon. The olfactories appear rather smaller than in most rodents and project only about three mm. beyond the hemispheres. This is due in part to the unusual development of the anterior portion of the hemispheres themselves, in part to the fact that the olfactory lobes are closely appressed to the hemispheres. The olfactory crus is flexed dorsad and laterad, so that the two lobes are flattened against the cephalo-ventral aspect of the hemispheres, which latter are also flattened at the same region. The two olfactory crura are in close contact, but the lobes diverge dorsally. This appression of the olfactory lobes may be due to the enormous development of the front part of the skull. The inflation of the skull in the region of the nasal cavities and above them could readily crowd so closely upon

*R. Owen, "On the Structure of the Brain in Marsupials," Philosophical Transactions, MDCCCVII, p. 93, Plate V.

†"Comparative Anatomy and Physiology of Verterbrates," Vol. III, p. 110.

the brain cavity as to cause the projecting olfactory lobes to be reflexed. The olfactory bulb is about 6 mm. in diameter, narrowing posteriorly into the crus, and is thickly covered on the whole cephalic and ventral surface with the roots of the olfactory nerves.

The Prosencephalon. The general form is hemispherical, each cerebral lobe being flattened on the median and ventral aspects. The great development of the front part of the cerebrum is the most striking feature of the brain. The ventral surface is unusually flat and broad. The pyriform and postrhinal lobes are not high, giving this surface a very different appearance from that of the brains of the rabbit or Guinea-pig.

The dorsal surface of the hemispheres is unconvoluted; on their ventral surface the rhinalis and postrhinalis form a continuous and strong fissure running their whole length. The compression in the region of the Sylvian fissure so conspicuous in most rodents is here reduced to a minimum. No trace of the Sylvian fissure itself is noticeable on the dorsal aspect; it is however, described and figured by Owen* in the case of Hystrix cristata as well marked, though short. But there is on the ventral surface a shallow, though well defined, fissure running from the chiasm laterad to the rhinalis, where it stops abruptly. The pyriform lobe thus sharply defined is about 15 mm. wide at the widest part opposite the hypophysis. Other small fissures on the ventral aspect are occasionally present, but very variable. On the median surface of the hemisphere the callosum is bounded on the dorsal and caudal aspects by the so-called callosal fissure. Passing ventrad from the splenium of the callosum the hippocampal fissure is well marked. Caudad to the hippocampal fissure is another small fissure passing caudo-dorsad to a point about as high as the splenium, apparently a suggestion of the splenialis. On the olfactory crus are two superficial tracts of lighter color; the smaller and shorter passes caudad and mesad, the other can be traced caudad and laterad as far back as the chiasm. Their relations are discussed in the paragraph on the internal topography of the rhinencephalon. The hippocampus is essentially as in Geomys, and under that head this region will be discussed, as the true relations are more easily traced in that type.

*"Comparative Anatomy and Physiology of the Vertebrates," Vol. III, p. 110.

The Diencephalon. The thalami are larger in Erethizon than in Geomys, the cephalo-dorsal aspect being especially depressed in the latter case. They are somewhat dome shaped above, and each is covered on the dorsal aspect by the hippocampus as by a cap. The corpora geniculata are large and quite obvious superficially. The post geniculatum is more conspicuous in Erethizon; both are well developed in Geomys. The cinereum is a sub-elliptical body, with the cephalic end, which is bounded by the transverse fibres of the chiasm, flattened. Its lateral portions are not covered by the overlapping pyriform lobe as in the rabbit. The mammillary is unpaired, median, and but slightly elevated. It is separated from the rest of the cinereum by a special fissure. The hypophysis is attached at the centre of the cinereum. It is fungiform, 7 mm. long, 7 mm. wide, and 4 mm. high. The stipe passes obliquely caudo-ventrad into the caudal portion of the body of the hypophysis, which is separated from the cephalic portion by a deep fissure on the ventral aspect. The epiphysis is of the usual conical form, 4 mm. high. It is pigmented at the apex. The third ventricle passes up a short distance into the basal portion (Plate I, Fig. 3.)

The Mesencephalon is almost completely hidden, the cephalic members by the hemisphere, the caudal members by the cerebellum The cephalic members are longer, the caudal members wider and higher. This arrangement is very different from that of Arctomys, in which the cephalic members are much larger and occupy the position of both members in these types. The caudal members are there crowded back to a position almost ventrad of the cephalic (cf. Vol. V, Plate XIX, Fig. 1.)

The crura cerebri stand out with great distinctness, being exposed to a point nearly as far cephalad as the attachment of the hypophysis. They are divaricated both cephalad and caudad, giving rise to a depression which is hour-glass shaped, the posterior area perforata, lying between the cinereum and the pons.

The Epencephalon. The cerebellum is subellipsoidal. The flocculus is rather large, but projects scarcely at all beyond the lateral lobe of the cerebellum, nor is it separated from this lobe by bony partitions, as in most rodents. It lies in a very shallow cavity of the skull in close contact with the adjacent parts of the cerebellum.

The Metencephalon. The medulla is obovate, about as long as wide. On the ventral surface the pons and pyramids are strongly

marked. The lateral columns are greatly enlarged ventrad to the clava, forming the area ovalis of Wilder. The relations of the dorsal columns and the structures on the floor of the fourth ventricle are shown by Plate I, Fig. 3. The funiculus gracilis and the funiculus cuneatus fuse at the region of the calamus scriptorius to form the clava, which is very large. The obex is also large, lying ventrad of the preceding. On the floor of the ventricle the fasciculi teretes are divaricated caudad by the projecting genua of the seventh nerve. The eminentia acustica are large and double, being divided into two portions by a longitudinal fissure. The striæ medullares are hardly visible in Erethizon; in Geomys they are very large. The posterior peduncle of the cerebellum passes into the restiform tract in the usual way.

The cranial nerves are illustrated by Plate I, Fig. 6. The optic nerves are smaller than usual, 1.2 mm. in diameter, 1 cm. from their insertion. The third nerves are about the usual size, inserted 1 cm. caudad of the chiasm on the ventral aspect of the crura. The fourth nerves are very small, pursuing the usual course. The fifth is large, 3 mm. in diameter at insertion, rapidly flattening out to much wider. It has two roots. The median is ventral and smaller and crosses the other at the Gasserian ganglion. The sixth is small, inserted just caudad of the pons about 3 mm. from the meson. But one root is apparent. The seventh is inserted on the caudal margin of the pons laterad of the sixth. The eighth is inserted 1 to 2 mm. caudo laterad of the seventh. There are two roots, which lie in very close contact. The ninth, tenth and eleventh are closely associated in their exit. The ninth is small and more easily separated from the other two. The tenth has several large roots which are hard to separate from those of the eleventh. The eleventh itself can be followed as a large strand as far back as the third spinal, and for at least two thirds of this distance gives off frequent smaller fasciculi into the medulla and cord. The twelfth arises on the caudal aspect of the pyramids by about six roots.

Measurements. Total length, tip of olfactories to end of medulla, 46.5 mm.; olfactory to cerebellum, 33 mm., to pons, 29 mm., to hypophysis, 21 mm., to chiasm, 17.5 mm.; width of the two hemispheres, median, 35 mm., one-fourth distance from caudal end, 33.5 mm. three-fourths distance from caudal end, 32 mm.; length of crura exposed, 8 mm.; length of tuber cinerum, 7 mm.; width of tuber cinerum, 6.5 mm ; length of corpora quadrigemina, 7.5 mm.; width of

corpora quadrigemina, 9 mm., thickness of corpora quadrigemina through the crura, 11.5 mm.; thickness of hemispheres, 21 mm.; length of cerebellum, 15 mm.; width of cerebellum at the flocculi, 25.5 mm.; thickness of cerebellum, 13 mm.; length of flocculus, 7 mm.; length of medulla, 15.5 mm.; width of medulla, 16 mm.; thickness of medulla at pons, 10 mm.; cephalo-caudal width of pons, 5 mm.; width of cord at insertion of the third spinal nerve, 7 mm.

Geomys bursarius. This brain conforms very closely to the usual myomorphic type. The figures presented in Plate I show a close resemblance to that of a white rat, which is introduced for comparison, the most important differences being in the more closely appressed hemispheres, the rhomboidal cerebellum without projecting flocculi, the form and markings of the medulla, and the general compactness of the brain as a whole. The prominences on the ventral surface are more pronounced than in Erethizon. The general appearance is intermediate between that of Erethizon and that of the rabbit.

The Rhinencephalon is of the usual form. The short, club-shaped olfactory lobes project about 4 mm. beyond the hemispheres, and are 3.5 mm. wide and 5.5 mm. long on the ventral surface.

The Prosencephalon differs but little from that of the rat. Aside from the points already mentioned, the Sylvian fissure presents slight differences, being stronger and produced farther dorsad in the rat. In both cases it crosses the rhinalis. The rhinalis fissure, as in the rat, passes farther laterad than in Erethizon and is not so deep. The most noteworthy feature of the ventral surface is the prominent postrhinal lobe. The pyriform also appears more prominent than in Erethizon, partly because the ventral surface is not so flat, but recedes more abruptly at the sides.

The hippocampus, which is at best a complicated and troublesome region, is here reduced to very simple terms and it is hoped that the series of transverse sections in Plate III may materially aid in understanding its structure. The first description of the hippocampus in rodents which has come to my notice is that of Stieda.* A condensed translation of his account of it in the mouse is here inserted for convenience of reference, as follows: The two hemispheres may be compared to a single hollow body, whose cavity is in communication with the third ventricle. This hollow body extends caudad over

*Op. cit. Zeits. f. wiss. Zoologie, Bd. XIX.

the thalami, which thrust the adjacent ventral wall inward so as almost to fill the cavity. That part of the original cavity which is not thus lost is greatly reduced by the adhesion of the dorsal and ventral parts of the wall until only a narrow space remains on either side, the lateral ventricles. The portion of the lower wall which is invaginated appears, when the ventricle is opened, as an arched mass in its floor, the cornu ammonis. This lower wall is not simple, but is convoluted, forming a folded arch directed cephalad, stretched over the thalamus. Thus, imagine that the hollow body [secondary prosencephalic versicle] has had the lower wall on either side driven cephalad by a fold springing from behind in the direction of the arch of the thalamus opticus (Plate III, Fig, 4, *a.*) By this process there arise a lamina superior and a lamina inferior cornu ammonis (Plate III, Fig. 3, *le* and *li.*) The terms are strictly applicable in only a part of the course of these bodies, since the relation of the two laminæ is altered caudad, the upper becoming lateral, the lower median. [These two portions are parts of the gyrus fornicatus.] In comparing the Ammon's horn with other parts of the cortex a difference is obvious, especially in the inferior lamina, in that a second fold has taken place, intercalating a band of smaller cells than those of the remainder between the upper and lower laminæ. This is the so-called granular layer, or tænia cinerea cornu ammonis of Volkmann [gyrus uncinatus, Plate III, Fig 3, *gu.*] The two cornua meet and coalesce to some extent in the median line. The connection between the two cornua is chiefly due to the confluence of the layer of fibres and of large cells of the superior lamina. Far cephalad the layers of large and small cells of the inferior lamina also coalesce. The fibres arising in the Ammon's horn of either side arch over the thalamus and converge behind the callosum where they separate from the cornua and plunge obliquely into that part of the substantia cinerea anterior caudad of the collosum and cephalad of the thalamus. "In the region of the anterior walls of the third ventricle these gradually diverging bundles disappear behind the anterior commissure. They obviously, therefore, form a longitudinal commissure of the anterior ventral part of the hemisphere, the substantia cinerea anterior, with the posterior portion of the hemisphere. In other words they constitute the fornix." Stieda recognizes two bundles of fibres in the cornu ammonis, one longitudinal, the other transverse, one passing to the callosum, the other to the fornix. In carnivora Stieda states that the gray matter of the two cornua is not confluent.

Reference to Plate III will render these statements of Stieda clear in spite of the condensed form in which they are necessarily presented. The first fold mentioned by him, the primary fold of the hippocampus (Plate III, *a*,) does not appear in transverse sections to be a mere fold, or fissure, springing from behind; but it is complicated by the fact that its dorsal portion is pushed much farther cephalad than its ventral. The latter only passes as far as the level of the corpus mammillare (Figs. 3 and 4.) Cephalad of this region the lamina next the the lateral ventricle, which I have called lamina ectalis (the superior lamina of Stieda, Fig. 3, *le*,) is in direct continuity ventrally with the other, the lamina entalis (or lamina inferior of Stieda, Fig. 3, *li*.) The fact that the dorsal portion of the primary fold of the hippocampus appears in transverse sections to pass much farther cephalad than the ventral portion is due to the arched form of the hippocampus itself. By reason of this forward arch the caudal portion of the hippocampus appears in longitundinal section, the cephalic portion in transverse section in these figures. The laminæ ectalis and entalis together constitute the gyrus fornicatus. By means of this primary fold the hippocampus is pushed far cephalad under the callosum beyond the chiasm until it comes into direct continuity with the fornix body in the region of the lamina terminalis. The primary fold reaches almost to the end of the gyrus fornicatus, but in Fig. 1 has disappeared.

The true relations of the gyrus uncinatus are much more difficult to make out. It is formed, as Stieda says, by a secondary fold of the gyrus fornicatus; but it is not, like the primary fold, due to an invagination, or convolution. It is rather a reflected portion of the margin of the lamina entalis. This margin is folded back upon itself, the folded portion, i. e. the gyrus uncinatus, being reflexed ventrad and cephalad, so that the free margin of the latter lies next to the diencephalon and mesencephalon. The convexity of the fold is directed cephalad, and toward the caudal end of the hippocampus it apparently in transverse sections increases greatly in size. This appearance, however, is due to the arched character of the hippocampus by which the caudal portion is seen in longitudinal section, as above alluded to. That the gyrus uncinatus is a true fold from the gyrus fornicatus is not very obvious from these sections, since the gray matter of the two gyri is nowhere in direct continuity. Moreover the cell structure is essentially different, the gyrus fornicatus having typical flask-cells, but the gyrus uncinatus smaller deeply staining cells which

are narrowly flask-shaped or fusiform. The difference is emphasized in the sections by the fact that the gyrus uncinatus lies in a different plane from the gyrus fornicatus, and thus when the cells of the latter are cut longitudinally those of the former are almost always cut transversely. Perpendicular longitudinal sections of the mouse brain, however, show the two laminæ in much closer contact, and in the opossum the continuity is unbroken, especially cephalad, though in the caudal portion the arrangement is more like that of rodents. Old embryos of the rabbit, too, show the formation of the folds above described with great clearness. The gyrus uncinatus in these rodents thus appears to be more or less displaced, as well as folded. In the rabbit embryos referred to it would appear to originate as a thickening on the free edge of the gyrus fornicatus, which is thrust back as by some external resistance, both on the ectal and ental surfaces of this edge, but chiefly on the latter. The cells which connect the two portions at this stage appear to be subsequently lost or to be replaced by fibrous elements.

The confluence of the gray matter of the two hippocampi, which Stieda describes in the case of the mouse, does not occur here. The external fibre zones of the two sides do come into contact in the meson, but this is obviously merely a mechanical adhesion. I suspect that the confluence which Stieda observed was more apparent than real, though my own mouse sections show the two sides in much closer contact than in Geomys. Fiber zibethicus resembles the mouse in this respect, and in the configuration of the hippocampus as a whole.

Erethizon dorsatus presents a structure essentially like that described for Geomys, though somewhat more difficult to follow. The chief difference lies in the gyrus uncinatus, which is larger and overlaps the free margin of the gyrus fornicatus much more than in Geomys. In Arctomys monax there is considerable variation, though only in the relative position of the parts. It is illustrated quite fully in Vol. V, Plate IV, Fig. 1, .Plate V, Figs. 1, 2, and 3, Plate VII, Fig. 2, Plate X, Figs. 5 and 7, Plate XIX, Figs. 1 and 2.

Diencephalon and Mesencephalon. The relations here are essentially as in the rat. The thalamus is much smaller than in Erethizon, the cephalo-dorsal portion especially being abbreviated. The cinereum is nearly circular with the infundibulum passing through the centre. The chiasm is not so prominent as in Erethizon, though essentially

similar. The mammilare is single, median, and large, occupying the whole caudal part of the cinereum. The hypophysis and epiphysis were not observed. Both the prægeniculatum and the postgeniculatum are more prominent than in Erethizon, especially the latter. The caudal members of the corpora quadrigemina are covered by the cerebellum, the cephalic members are nearly covered by the hemispheres. The former are broader laterally, the latter are longer. They are of about equal hight.

The Epencephalon is compact, like that of Erethizon, but very different in shape. The median lobe is produced farther both caudad and cephalad, thus making the cerebellum considerably longer, and giving it a decidedly rhomboidal shape when looked at from above. In the flocculus it resembles Erethizon, thus differing widely from other myomorphs, whose flocculi are longstalked and encased in special cavities of the skull.

The Metencephalon is oblong, about as wide as long. Ventrally the pyramids do not stand out in as bold relief as in Erethizon, neither is the pons as sharply defined. On the dorsal surface, the clava is not so wide as in Erethizon, being crowded mesad by the larger lateral columns. The obex is small, but sharply defined. The eminentia acustica is large and the striæ medullares are very conspicuous. The fasciculi teretes and other structures of the floor of the fourth ventricle are not so prominent as in Erethizon. With reference to the nerve roots, the most important peculiarity is the unusually small size of the second pair. This is readily accounted for by the small size of the eyes and the nocturnal habits of the animal. The fifth nerves are easily separable into three fasciculi before they enter Gasser's ganglia. Of these the middle bundle is the largest.

Measurements. Total length, tip of olfactories to end of medulla, 22.5 mm.; greatest width of the two hemispheres, 16.5 mm.; length of hemisphere, 13.5 mm.; depth of hemisphere, 10 mm.; tip of olfactory to cerebellum, 16 mm.; tip of olfactory to pons, 14 5 mm.; tip of olfactory to hypophysis, 12.5 mm.; tip of olfactory to chiasm, 10 mm.; length of cinereum, 5 mm.; width of cinereum, 5.5 mm.; length of cerebellum, 9.5 mm.; width of cerebellum, 13.5 mm.; depth of cerebellum, 7 mm.; length of flocculis, 4.5 mm.; length of medulla, 7.5 mm.; width of medulla, 7 mm.; thickness of medulla at pons, 5 mm.; width of spinal cord, 4.5 mm.

INTERNAL TOPOGRAPHY.

In the following pages all statements apply both to Erethizon and to Geomys, unless otherwise indicated. Comparison was also made in many particulars with a series of sections of Fiber zibethicus.

Ventricles. The third ventricle is shown in its relations in median longitudinal section by Fig. 3, Plate I. The aqueduct of Sylvius is wide and there is a slight indication of a ventricle of the mesencephalon. The third ventricle is largely occupied by the medicommissure, particularly dorsally. Below, it passes into the infundibulum in the center of the cinereum. Cephalad of the chiasm there is another depression, which is superficially bounded by little more than a membrane. Dorsad, the third ventricle enters the epiphysis for a short distance. Cephalad of the medicommissure are the foramena of Monro, or portæ, shaded black in the figure. The lateral ventricles of the hemispheres envelop the striata on the dorsal and median aspects. The præcornua arch as far laterad as the cephalic ends of the striata. From their cephalo-ventral limits the aqueducts of the olfacfactory ventricles push out into the olfactory crura. The olfactory ventricles, though small, pass almost to the ends of the olfactory bulbs. The medicornua of the lateral ventricles are strong, enveloping the hippocampi on their lateral and dorsal aspects.

Olfactory Lobe and Tracts. The minute structure of the olfactory lobe seems to be essentially that described for Arctomys in Vol. V of this Bulletin, page 81. The specific olfactory, or ganglion cells, however, are not usually pyramidal, but irregularly fusiform or flask-shaped, with the apices directed peripherad.

The arrangement of the olfactory tracts is about the same in Erethizon, Geomys, Mus musculus, and Fiber zibethicus. It can best be described in Geomys. Transverse sections of the olfactory bulb (Plate II, Fig. 4) show within the fibres of the olfactory nerves the usual glomerular layer containing sparse, small, pyramidal cells, a layer of ganglion cells in a single series, whose bases lie in a thin granular zone of Deiter's corpuscles. This zone is separated by another thin band of the neuroglia layer from the dense central mass of laminated Deiter's cells which fills up the rest of the bulb except a loose medullary portion about the ventricle.

Fibres destined for the superficial olfactory tracts, or radices, gather well out in the olfactory bulb into a bundle which lies in the

internal laminated layer of Deiter's cells dorsad of the ventricle (Plate II, Fig. 4, *rxl.*) These soon form a strong band which swings laterad and finally ventrad of the ventricle, as it passes caudad (Plate II, Figs. 5 and 6) As the olfactory crus begins to fuse with the hemisphere, the superficial olfactory tract takes a position on the ventral surface of the latter, at the same time dividing into two fasciculi. A small median bundle, radix mesialis, (Plate II, Fig. 6, *rxm*; see also Plate I, Fig. 1) can be traced on the ventro-median surface of the hemisphere as far back as the cephalic end of the callosum. From both transverse and perpendicular longitudinal sections it appears as if its fibres pass dorso-caudad from this point into the septum lucidum, entering it from below between the cephalic terminus of the callosum and the anterior commissure. The fibres, however, have not in any case been actually traced through the whole of this course. Even if this be not the true course of these fibres, it seems hardly possible that the same relation could here prevail as in the opossum, where this radix passes directly through the brain cortex up to the gyrus fornicatus. The larger bundle radix lateralis, passes laterad and caudad toward the pyriform. As it passes into this lobe, it loses its compact form and spreads out over its ventral surface. It can be traced nearly to the caudal end of the pyriform. The inference is that these fibres dip into the pyriform along its whole ventral surface, especially toward the cephalic end, though this has not been actually observed.

Returning to the olfactory crus, a section taken through its middle portion shows the following structures (Plate II, Fig. 5.) The structure of the median half is the same as that of the olfactory bulb. The lateral surface is covered with the superficial olfactory tract *rxl* and remains of the glomerular layer. Entad of this tract is a cortical structure, *c*, like that of the hemisphere of which it is really a part. Still further entad, adjacent to the ventricle, are fasciculi of the præcommissural tract of the olfactory crus, *pc*. That this cortex is not only similar to but identical with that of the hemisphere is shown by sections taken at the point of union of the olfactory crus with the hemisphere (Plate II, Fig. 6,) where its continuity is demonstrated. At this point it makes up the body of the crus. Passing outward (cephalad,) it is gradually displaced by the various layers of the olfactory bulb, crowded to the dorsal surface, and finally in the bulb itself disappears entirely. The internal, or præcommissural olfactory tract lies within this mass of cortical cells, and I have not been able to trace its

fibres beyond them. It has been suggested by my brother, who first observed this relation in the opossum, that this is not necessarily a true olfactory tract, but may be the tract of this portion of the cortex.* It passes caudad, sinking into the substance of the brain ventrad of the striatum, finally enters the base of that body, and continues its course, as a large well defined bundle, to the anterior commissure (Plate II, Figs. 2, 7, and 8, *pc.*)

The Anterior Commissure contains two sets of fibres. The cephalic and slightly larger bundle has been already described in connection with the olfactory tracts. The caudal branch arches backward, its fibres passing caudo-laterad along the ental border of the lower portion of the striatum. They can be followed as far back as the chiasm. In Geomys these two bundles fuse so that in the body of the commissure they cannot be distinguished. On the other hand in Mus musculus and Fiber zibethicus they remain distinct through the whole length of the commissure, and can be easily distinguished in transverse section when the brain is cut perpendicular longitudinally (*cf.* Plate II, Fig. 1.) The commissure, after the union of its two portions, curves gently dorsad, so that its highest point is in the meson. In Erethizon the same relation prevails as in Geomys, though somewhat obscured by the enveloping fibres of the striatum at the point of separation of the two bundles (Plate II, Fig. 3.)

The Callosum is as usual among rodents. It is, however, considerably larger in Erethizon than in Geomys, in the former case being thicker than the fornix commissure, in the latter scarcely as thick. It extends caudad to a point as far back as the superior commissure. In Erethizon its cephalo-caudad length is 14 mm, in Geomys, 6 mm.

The Striatum is a pear-shaped body with the more convex surface entad and the larger end cephalad. The dorsal aspect is arched and quite free from the surrounding organs. The ventral surface is not so sharply defined, but passes into the substance of the hemisphere. It is connected with the thalamus on the caudo-ventral aspect by the pyramidal tracts from the peduncle. The anterior commissure crosses

*See a paper on the Brain of the Opossum, by C. L. Herrick, in the forthcoming number of the Journal of Comparative Neurology. According to this view, the various layers of the olfactory bulb, constituting the pero of Professor Wilder, are mechanically superposed upon the pes, or cortical and ventricular portion of the olfactory, without sustaining any vital relation to it.

I am also indebted to this paper for all comparative data with the opossum which occur in this article.

from the most ventral part. As Stieda says, the cephalic portion of the two striata are connected by the septum lucidum; but in these brains it is only the most ventral parts which are thus connected, since the anterior cornua of the lateral ventricles separate them dorsally and ventrad to these cornua the position of each is occupied by a loose reticulum of fibres lying chiefly in the direction of the ventricle.

The gray, or nonfibrous portions of the striatum contain numerous small cells, about half the size of the pyramidal cells of the cortex adjacent. Their forms vary, being chiefly pyramidal or fusiform, with the cell body almost perfectly transparent, but the nucleus and nucleolus stain very deeply. The nucleus, however, is not elongated, as in the pyramidal cells of the cortex, but circular, resembling both in size and shape the Dieter's cells which are very numerous in the striatum.

The Fornix is very large in these types, as in all rodents, and appears to take the usual course. Fibres of the descending fornix tracts are gathered into two firm bundles dorsad of the anterior commissure and pass out caudo-ventrad from the ventro-lateral angles of the fornix body. They pass rapidly caudad to the end of the cinereum, then dip abruptly downward into the mammilliary. The latter body is unpaired externally. Internally its two cell-clusters, or niduli, are rather ill-defined and fuse in the meson ventrally. The descending fornix tracts passing ventrad envelop the niduli of the mammillare on their ectal and ventral aspects, at the same time sending fibres into their substance. The fibres of the ascending fornix tracts gather on the mesal and cephalic aspects of these niduli into close bundles which pass cephalo-dorsad and at the same time laterad in such a way as to form the usual figure-of-8 curve. This arrangement prevails in the opossum and conforms in the main with the description given by Meynert for the human brain.* By reason, however of the great size of the ciner-

*Stricker's Histology, American edition, 1872, p. 689. "The corpus candicans (s. mammillare) is a ganglion, which lies in a loop made by the anterior pillar of the fornix in twisting back upon itself (to enter the thalamus,) and by its means a certain number of the fibres of the fornix are made to pass directly into the tegmentum cruris cerebri. It is a mistake to suppose, with Jung, that fibres from the fornix simply traverse the substance of the corpus candicans, and that the superficial nerve-fibres which enclose the latter are to be referred to a different source. On the contrary, the descending branch of the crus fornicis first invests the outer and posterior surface of the ganglion, and then twisting on itself, invests, under the form of the ascending branch of the same crus, the inner and anterior surfaces."

eum in rodents, the mammillare is pushed far caudad and, in fact, lies ventrad of the commisure of the optic lobes. Thus the ascending fornix tract, passes up in the most caudal part of the thalamus, instead of the cephalic part, as figured by Meynert. Plate II, Fig. 2, illustrates this ascending tract, lying between the caudal end of the third ventricle and the descending fornix tract, *f*.

Optic Tracts. Enveloping the dorsal and caudal aspects of the chiasm is a dense cluster of very large multipolar cells, which in the opossum has been called the anterior nidulus of the cinereum. They are enveloped in a very loose reticulum of fibres which is quite free from cells of other sorts. This causes their strong protoplasmic processes to stand out with especial distinctness. The optic tract passes laterad from the chiasm to the edge of the thalamus, thence dorsad as a compact bundle on its lateral aspect. It passes obliquely dorso-caudad over the prægeniculatum, then over the dorsal surface of the postgeniculatum, sending small fasciculi of fibres through both of these bodies back to the optic lobes. The rest of the fibres pass over the dorsal surface of the thalamus, entering the optic lobe on their cephalic aspect.

The Medicommissure, or soft commissure, fills nearly the whole of the dorsal portion of the third ventricle. As is often stated, it is merely an adhesion of the sides of the thalami in the median line; yet so intimate is the contact that considerable force is necessary to separate them in Geomys, and in Erethizon this could hardly be effected at all. Sections, moreover, reveal no internal break in the continuity of the substance of the thalami at this place, the meson being occupied by cells and fibres like the adjacent parts. In dissecting overhardened brains of the rat, however, the medicommissure some times falls apart of its own accord. It is nearly circular in section, in Erethizon about 6.5 mm. in diameter, in Geomys, 3 mm.

Habenæ. Each habena is a club-shaped body lying on the cephalo-dorsal aspect of the thalamus. Their larger ends are directed caudad and terminate near the median line immediately under the cephalic crus of the epiphysis and the superior commissure. The smaller ends gradually diverge as they pass into the tænia thalami and down over the cephalic face of the thalamus. Microscopically the habena consists of two sharply differentiated parts. The median portion is very densely packed with small cells which stain intensely. This is the nidulus of the habena. The lateral and cephalic portions

are occupied chiefly with fibres, especially ectad. There are also scattered cells lying laterad and ventrad of the nidulus of the habena, which stain very feebly. These are multipolar or bipolar, with occasional flask-cells like those of the rest of the thalamus. Meynert's bundle enters this nidulus from behind. This seems to be what has been described in Vol. V of this bulletin, page 76, as the nidulus of Meynert's bundle, though differing considerably in form and position from the arrangement there presented. This nidulus of Meynert's bundle has also been described in reptiles, though there much further caudad and ventrad.*

The fibres of Meynert's bundle pass caudad beneath the tænia receiving some fibres from the latter, as far as the superior commissure. At this point they turn abruptly, pass caudo-ventrad through the thalamus, cross the fibres of the third nerve near their exit, and disappear. The tænia thalami pass cephalo-ventrad from the crus of the epiphysis, lying dorsad of the median, denser cell-cluster, or nidulus of the habena. They take the usual course, passing ventrad and laterad and at least at first somewhat caudad behind the anterior commisure, soon to be lost among the peduncular fibres.

The Commissural Apparatus of the Habenæ and Optic Lobes. In this region there are two commissural systems, the first cephalad, the second caudad of the epiphysis. The first system comprises the superior commissure and the commissure of the habenæ. These commissures are distinct in the lizard,† but in these types are fused. The whole may here be called the superior commissure. It is horseshoe shaped, the convexity being caudad and dorsad. Plate II, Figs. 9 to 12, illustrates these commissural systems in Geomys. Fig. 10 shows fibres from the lateral parts of the habenæ arching caudo-dorsad toward the meson, which, however, they do not quite reach at this level. Fig. 11

*C. L. Herrick, "Topography and Histology of the Brain of Certain Reptiles," Journal of Comparative Neurology, Vol. I, p. 26.

"If the superior projecting portion of the habena surrounding the base of the stalk of the epiphysis be considered the habena proper, the deeper and more ventro-caudad portion may be distinguished as the nidulus of Mynert's bundle, or nidulus Meynerti. The fibres of Meynert can be traced to the portion mentioned (which in the black snake forms a distinct nidulus.) The cells are rather larger than those of the habena, and less compactly clustered about the walls of the third ventricle extending some distance ventrad."

†C. L. Herrick, loc. cit.

illustrates this commissure in its middle course slightly dorsad to Fig. 10. The cephalic crus of the epiphysis passes up from the highest point of this commisure. In Erethizon this commisure seems to be stronger and lies well up in the stalk of the epiphysis, the fibres arching much higher than in Geomys.

The second commissural system caudad of the ventricle of the epiphysis, is represented by the posterior commissure in the caudal crus of the epiphysis and the commissure of the optic lobes Sylvian commissure in the substance of the corpora quadrigemina dorsad of the aqueduct of Sylvius. The posterior commissure is a very strong band forming the roof of the third ventricle below the epiphysis, and also arching up into the caudal crus of that body. Its fibres pass ventrad and caudad into the substance of the optic lobes. The commissure of the optic lobes consists for the most part of sparse fibres passing latero-caudad into the dorsal portions of the optic lobes. At its cephalic end, fibres dip directly ventrad, arching slightly caudad, then cephalad in the substance of the tegmentum to a point cephalad of the peduncular nidulus. It is not a strong commissure and its fibres do not lie in immediate contact with the epithelium of the ventricle, as do those of the posterior commissure. Cephalad, the commissure of the optic lobes, seems to be almost, if not quite, continuous with the posterior commissure, being distinguished from it by its fewer fibres, its position removed from the ventricle, and the direction of its fibres. In the opossum, however, the continuity is distinctly broken dorsad of the cephalic end of the aqueduct. Figs. 9 and 14 of Plate II illustrate the posteror commissure; Fig. 10, the cephalic fibres of the commissure of the optic lobes; Fig. 11, the sparse fibres of this commissure in the middle portion of its course; Fig. 12, its caudal end, the fibres connecting the caudal members of the corpora quadrigemina. It is stronger and more compact here than any where else in its course.

Cranial Nerves. The internal course of the nerve roots, so far as observed, conforms in general to the usual descriptions. The course of the third is beautifully shown by transverse sections of Geomys (Plate III, Fig. 5.) Its nidulus lies immediately dorsad of the dorsomedian fasciculus, the fibres of which pass through its lower portion. It is very small and sharply defined. The fibres passing down arch laterad and pass through the median portion of the large peduncular nidulus. The cells of the latter are very large and multipolar, being

much more angular and irregular than the equally large cells of the third nidulus. The nidulus of the fourth also lies immediately dorsad of the dorso-median fasciculus under the aqueduct, but considerably caudad of the third. It is not in contact with the nidulus of the third, neither is it separated from it by fibres of the dorso-median fasciculus, as in Arctomys (Vol. V, Plate X, Fig. 1.) The fibres take the usual course to the value of Vieussens. The course of the fifth has not been traced in detail. The sixth nerve springs, as in Arctomys (Vol. V, Plate XVII, Fig. 2,) from a small nidulus in the loop formed by the genu of the seventh. Its fibres descend in several fascicles to a common exit. The seventh takes the usual course, passing first to the genu, which projects into the ventricle entad of the nidulus of the sixth, then turning abruptly ventrad in many strands to its nidulus in the ventral part of the medulla. The course of the eighth agrees pretty closely with Arctomys, as described by Prof. Tight in Vol. V, pages 58 and 59. The nidulus of the root of the eighth nerve lies cephalad and dorsad of most of the fibres as they enter the medulla. The fibres of the most cephalic portion of the root pass through this nidulus and into the cerebellum. A little farther caudad fibres pass directly mesad under the caudal crus of the cerebellum as it enters the restiform body, some turning up into the cerebellum, some passing farther mesad toward the ventricle. Farther caudad these fibres pass through Deiter's nidulus, then mesad to the eminentia acustica. Deiter's nidulus lies immediately entad of the crus of the cerebellum at this point, with large deeply staining multipolar cells. Still farther caudad the great mass of the fibres of the eighth pass up and arch over the crus of the cerebellum directly into the eminentia acoustica, Deiter's nidulus having disappeared. The ninth and tenth roots are as hard to distinguish internally as externally. Their fibres pass dorso-mesad to a nidulus near the floor of the ventricle. The eleventh was not traced. The twelfth niduli lie immediately below the ventricle at the region of the calamus scriptorius. Their large multipolar cells lie in a clear stroma, and the two niduli are confluent in the meson. The fibres descend in many bundles to their exits, passing by the olives on the cephalo-lateral aspects of the latter.

Explanation of Plates.

PLATE I.

Figures 8, 9, and 10 of this plate were drawn by C. L. Herrick.

Fig. 1. Brain of Erethizon dorsatus, ventral view, with the hypophysis, without the medulla and cerebellum, twice natural size.

Fig. 2. Region of the calamus scriptorius of Erethizon dorsatus, cerebellum removed, twice natural size; *r*, recessus lateralis; *p*, pedunculus cerebelli in section; *t*, fasciculus teres; *a*, eminentia acustica; *g vii*, genu of the seventh nerve; *o*, obex; *cl*, clava; *c*, calimus scriptorius; *gr*, furniculus gracilis; *cu*, furniculus cuneatus; *lc*, lateral columns.

Fig. 3. Brain of the Erethizon dorsatus, hemisected, median view, cerebellum removed, natural size; *c*, callosum; *f*, fornix commissure; *pc*, præcommissure; *mc*, medicommissure; *h*, habena; *p*, pedunculus cerebelli in section; *r*, recessus lateralis.

Fig. 4. Brain of Erethizon dorsatus, dorsal view, natural size.

Fig. 5. Brain of Geomys bursarius, ventral view, hypophysis removed, twice natural size; the Roman numerals refer to cranial nerve roots.

Fig. 6. Brain of Erethizon dorsatus, ventral view, hypophysis removed, twice natural size. The exit of the third nerve is abnormally on the lateral aspect of the crus in this brain, by reason of the fact that after leaving the brain it turns laterad some distance before penetrating the membrane; cf, Fig. 1.

Fig. 7. Brain of Erethizon dorsatus, lateral view, natural size.

Fig. 8. Brain of the white rat, dorsal view, natural size.

Fig. 9. Brain of Geomys bursarius, dorsal view, natural size.

Fig. 10. Brain of Geomys bursarius, lateral view, natural size.

PLATE II.

The outlines of all figures of this plate were drawn with the aid of the camera lucida.

Fig. 1. Horizontal longitudinal section of the brain of Mus musculus at the level of the anterior commissure.

Fig. 2. Horizontal longitudinal section through the brain of Geomys bursarius at a level slightly ventrad of the anterior commissure; *rxl*, radix lateralis, or lateral olfactory root; *pc*, praecommissural tract of the olfactory; *op*, optic tract; *f*, descending fornix tract entering the mammiliary.

Fig. 3. Horizontal longitudinal section through the brain of Erethizon dorsatus at the level or the anterior commissure, drawn to the same scale as *Fig.* 13;

f, descending fornix tract shortly after leaving the fornix body; *op*, optic tract; *M*, Meynert's bundle; *III*, peduncular nidulus of the third nerve.

Figs. 4, 5, 6, 7, 8. A series of transverse sections through the brain of Geomys bursarius, drawn to a uniform scale, which is found under Fig. 5.

Fig. 4. Transverse section through the olfactory lobe; *rxl*, fibres of the radix lateralis (really the combined superficial olfactory tracts, *gr*. laminated granular layer; *g*, ganglionic layer; *n*, neuroglia, or gelatinus layer.

Fig. 5. Transverse section through the olfactory crus; *c*, cortex of the olfactory crus; *pc*, praecommissural tract of the olfactory; *rxl*, radix lateralis.

Fig. 6. Transverse section at the point of union of the olfactory crus with the hemisphere; *rxl*, radix lateralis; *pc*, praecommissural tract; *rxm*, radix mesalis, or medial olfactory root.

Fig. 7. Transverse section through the hemisphere cephalad of the callosum; *rxl*, radix lateralis; *pc*, præcommissural tract; *rxm*. radix mesalis.

Fig. 8. Transverse section just cephalad of the anterior commissure; *rxl*, radix lateralis; *pc*, praecommissural tract; *f*, fornix body; *c*, callosum.

Figs. 9, 10, 11, 12. A series of horizontal longitudinal sections through the brain of Geomys bursarius, illustrating the commissural apparatus of the habenæ and optic lobes, all drawn to the same scale as Fig. 2.

Fig. 9. Horizontal section through the thalamus and corpa quadrigemina at the level of the posterior commissure, which lies in the centre of the figure; *t*, tænia thalami beginning to descend from the habena; *op*. optic tract.

Fig. 10. Horizontal section through the entire brain immediately dorsad of Fig. 9; fibres of the superior commissure arch caudo-dorsad from the habenæ toward the meson; at the cephalic terminus of the corpora quadrigemina are fibres of the commissure of the optic lobes, just cephalad of which is a small triangular depression which marks the boundary between the optic lobes and the thalamus.

Fig. 11. Horizontal section through the thalami and corpa quadrigemina immediately dorsad of Fig. 10; *sc*, supracommissure; *op*, optic tracts; a few scattered fibres of the commissure of the optic lobes appear in the center of the figure.

Fig. 12. Horizontal section through the corpora quadrigemina taken near their dorsal limit; the dorso-median fissure has separated the cephalic members; the caudal members are connected by a strong bundle of fibres of the commissure of the optic lobes.

Fig. 13. Horizontal longitudinal soction through the brain of Erethizon dorsatus dorsad of the last, slightly inclined ventro-cephalad; *tth*, taenia thalami; *op*, optic tracts.

Fig. 14. Transverse section through the brain of Erethizon dorsatus at the region of the posterior commissure, which lies immediately above the third ventricle; *M*, Meynert's bundle; *p*, pyramidal tracts.

Fig. 15. Perpendicular longitudinal section through the brain of Erethizon dosatus taken slightly laterad of the meson; *sc*, supracommissure; *M*, Meynert's bundle; *III*, exit of the third nerve with the peduncular nidulus.

PLATE III.

A series of six transverse sections through the brain of Geomys bursarius, drawn to a uniform scale with the aid of the camera lucida, illustrating the hippocampus and tracts of the mesencephalon. The letters have the same value in all figures; *a*, primary fold of the hippocampus; *ch*, anterior part of chiasm; *cop*, commissure of the optic lobes; *f*, descending fornix tract; *gu*, gyrus uncinatus; *ipn*, interpeducular nidulus; *le*, lamina ectalis (superior); *li*, lamina entalis (inferior;) *M*, Meynert's bundle; *n III*, nidulus of the third nerve; *op*, optic tract; *pn*, peduncular nidulus; *rxl*, radix lateralis olfactoria; *sc*, superior commissure; *III*, exit of third nerve.

Fig. 1. Transverse section immediately cephalad of the chiasm.
Fig. 2. Transverse section at the level of the superior commissure.
Fig. 3. Transverse section through the caudal end of the third ventricle.
Fig. 4. Transverse section at the region of the mammillary.
Fig. 5. Transverse section at the level of the third nerve.
Fig. 6. Transverse section slightly caudad of the last.

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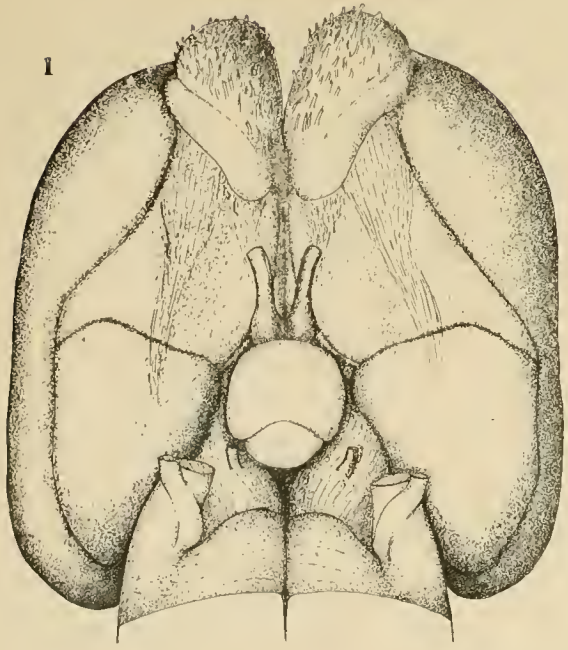

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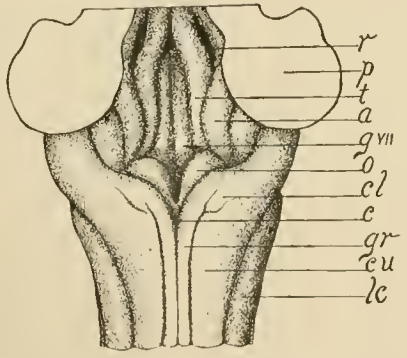

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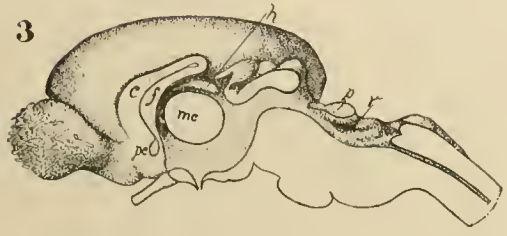

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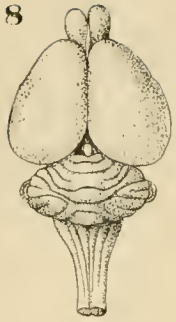

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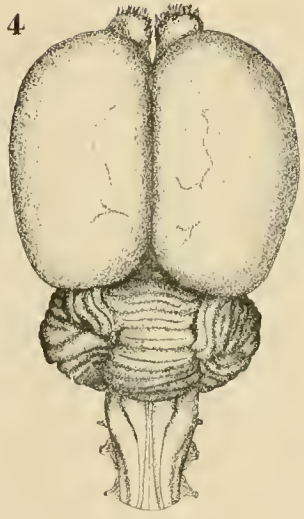

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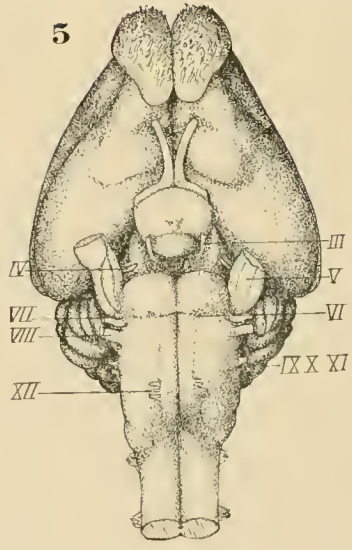

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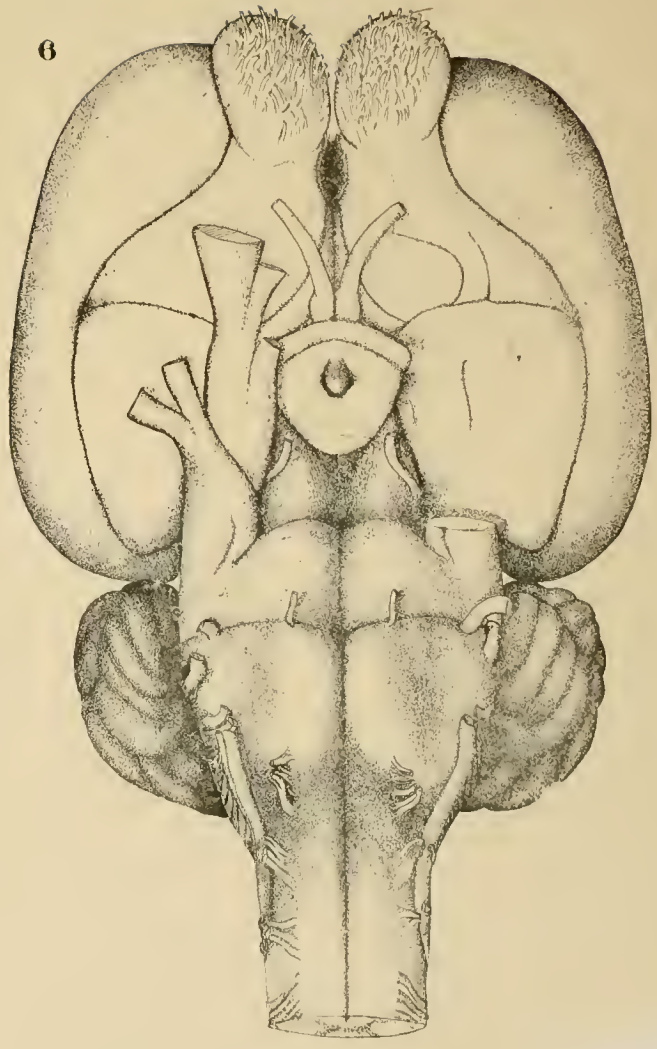

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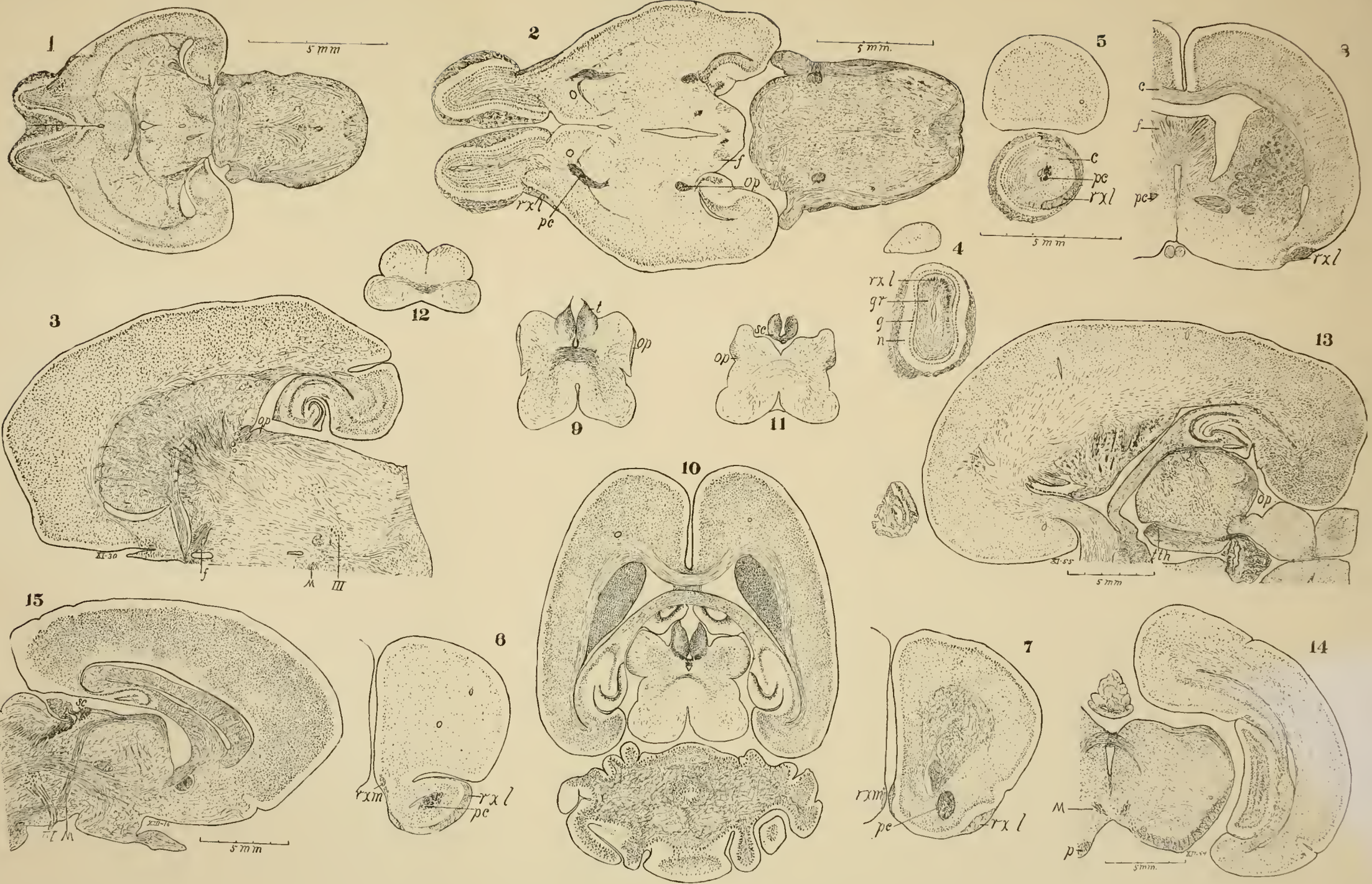
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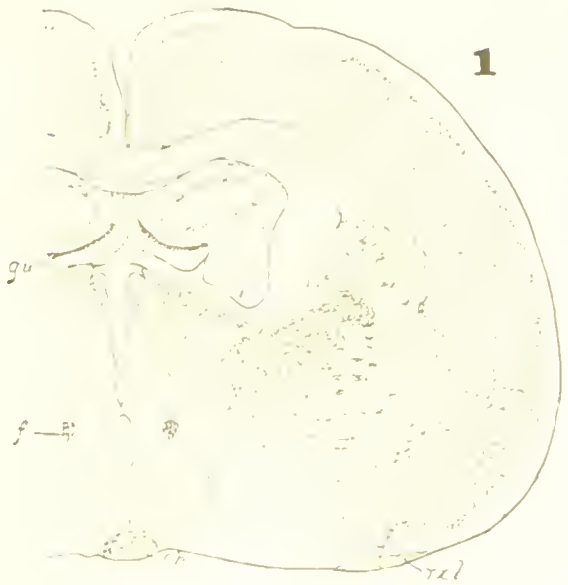
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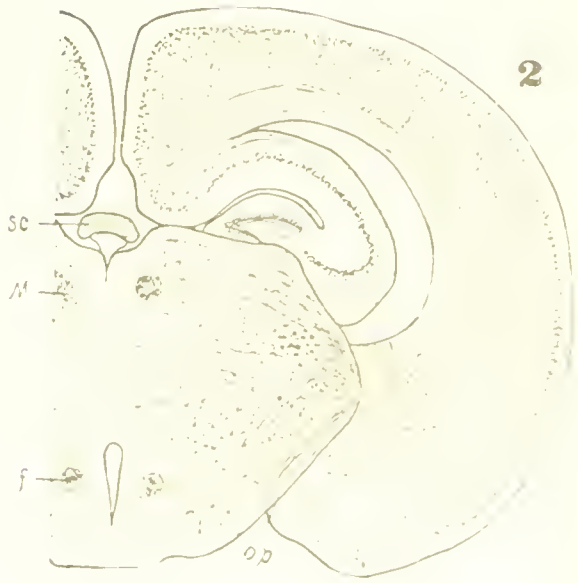
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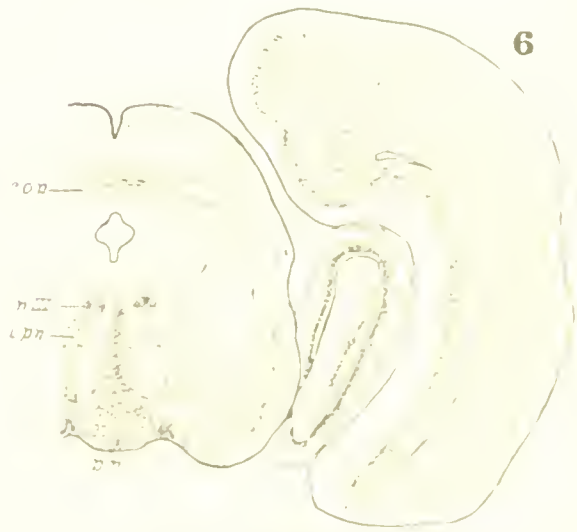
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Meteorological Observations at Granville.

The results gathered together in the following pages form a summary of the observations of local observers working under the direction of the Ohio Meteorological Bureau, from whose publications they are taken. It was thought that it would be of value to have all possible information concerning this one locality brought together so that comparisons can be easily made when the data have been accummulated sufficiently to make them useful. It was hoped that we might find the record of certain observations made privately—according to local traditions—a good many years ago, but these have not yet been brought to light. The work connected with the State Bureau was begun when the latter was founded in October, 1882. The late C. W. Bryant started the Granville station, but in January, 1883, Prof. J. L. Gilpatrick began to take observations and continued them until June, 1886, when M. P. Ashbrook succeeded him. His removal from the State soon after caused a break in the observations from Nov. 1, 1886 to Dec. 1888. At this time the Denison Scientific Association undertook to obtain an observer and secure the continuation of the interrupted work. W. H. Herrick then began to take the readings. Since then under its direction Mr. Sanford, E. U. Smith and A. H. Bartle have at different times had charge of the work. The desire to have their instruments in the best possible locality in this vicinity, the extreme top of College Hill, has made the taking of the readings quite laborious, and accounts for the difficulty experienced in securing perfect continuity in the observations, or long periods of service from the same observer.

SUMMARY FOR NOVEMBER AND DECEMBER, 1882.

	Nov	Dec.		Nov	Dec.
Mean Relative Humidity	83.8	87.1	Number of Clear Days	5	4
Mean Temperature	38.0	27.3	Number of Fair Days	13	14
Highest Temperature	71.5	51.2	Number of Cloudy Days	12	13
Date	11th	21st	Number of Days Rain Fell	12	10
Lowest Temperature	14.2	6.4	Total Rainfall	1.33	2.03
Date	25th	8th	Average Daily Rainfall	.044	.065
Range of Temperature	57.3	57.6	Prevailing Direc'n of W'ds	SW	SW
Mean Daily Ran. of Temp.	14.7	15.5			

SUMMARY FOR THE YEAR 1884.

	Jan.	Feb.	Mar	Apr.	May	June	July	Aug	Sept	Oct.	Nov	Dec.
Mean Realative Humidity	84.9	88.1	87.6	86.3	69.5	72.3	64.5	61.1	65.9	71.5	77.5	87.8
Mean Temperature	18.7	34.1	36.6	47.9	61.1	71.7	72.2	73.2	70.4	56.9	37.8	29.4
Highest Temperature	51.0	62.0	64.5	73.4	85.0	93.0	90.0	94.5	93.5	87.0	64.0	58.3
Date of Highest Temperature	31st	12th 19th	25th 28th	30th	22d	23d	22d 23d	20th	8th	3d	10th	30th
Lowest Temperature	16.3	3.0	0.9	21.6	34.7	51.0	52.0	46.0	40.0	24.0	12.0	19.5
Date of Lowest Temperature	5th	29th	4th	3d	29th	15th	8th	11th	19th	24th	24th	19th
Range of Temperature	67.3	65.0	64.5	51.8	53.3	42.0	38.0	48.5	53.5	63 0	52.0	77.8
Mean Daily Ran. of Temperat're	17.5	17.1	15.2	19.9	21.1	23.3	20.6	24.3	24.4	19.7	18.2	15.6
Number of Clear Days	7	3	4	9	17	15	13	22	16	21	14	4
Number of Fair Days	7	7	9	12	7	9	16	9	9	5	5	11
Number of Cl'dy Days	17	19	18	6	7	6	2	----	5	5	11	16
Number of Days Rain Fell	11	16	16	8	9	7	5	8	8	9	7	11
Total Rainfall	----	5.72	3.00	1.95	5.77	3.06	2.57	.75	3.37	1.23	1.23	3.90
Prevailing Direction of Wind	SW	W	S	W	W	S	NW	SW	S	W	W	W

*SUMMARY FOR THE YEAR 1883.

	Jan.	Feb.	Mar	Apr.	May	June	July	Aug	Sept	Oct.	Nov	Dec.
Mean Relative Humidity	84.0	84.6	82.9	75.9	76.0	74.0	70.0	64.7	66.4	79.0	79.1	88.9
Mean Temperature	23.5	30.3	31.4	48.9	58.1	68.6	72.2	69.4	63.6	53.2	42.7	32.3
Highest Temperature	54.0	70.9	65.0	86.0	84.7	86.0	91.0	92.5	89.0	80.8	70.0	56.0
Date of Highest Temperature	27th	16th	18th	14th	9th	16th	3d	22d	14th	9th	9th	6th
Lowest Temperature	-1.5	6.0	5.0	21.9	32.7	43.0	43.0	40.0	36.7	31.0	9.0	7.0
Date of Lowest Temperature	22d	1st	20th	2d	22d	14th	31st	30th	9th	21st	16th	22d
Range of Temperature	55.5	64.9	60.0	64.1	52.0	43.0	48.0	52.5	52.3	49.8	61.0	49.0
Mean Daily Range of Temp	16.3	15.2	18.8	20.8	22.0	21.1	21.8	23.6	23.6	16.3	17.2	15.5
Number of Clear Days	2	6	9	9	11	11	23	18	10	8	10	9
Number of Fair Days	12	9	12	11	13	15	7	11	13	8	12	7
Number of Cl'dy Days	17	12	10	10	7	4	1	2	7	15	8	15
Number of Days Rain Fell	15	9	7	6	9	5	9	3	8	9	9	13
Total Rainfall for the Month	3.45	5.34	2.78	2.33	4.47	1.87	3.33	.70	2.63	4.53	3.36	3.76
Average daily Rainfall	.111	.191	.090	.078	.144	.062	.107	.023	.088	.146	.112	.121
Prevailing Direction of Wind	W	NW	W	WN	SW	SW	W	NW	NW	N	S	W

*NOTE—That the order of the Summaries for the years 1883 and 1884 are transposed.

SUMMARY FOR THE YEAR 1885.

	Jan.	Feb.	Mar	Apr.	May	June	July	Aug	Sept	Oct.	Nov	Dec.
Mean Relative Humidity	84.1	82.5	81.0	86.7	79.0	73.6	68.2	----	73.9	76.2	82.6	84.6
Mean Temperature	22.6	18.6	28.5	48.3	60.6	67.7	75.5	----	65.3	50.4	40.4	31.5
Highest Temperature	56.0	50.0	58.0	82.0	85.0	90.0	93.0	----	83.5	76.0	67.0	59.0
Date of Highest Temperature	6th	28th	31st	23d	17th	7th	17th	----	26th	1st	7th	9th
Lowest Temperature	-10.0	-12.	-2	22	33.0	43.	46.	----	37.0	27.5	20.0	-1
Date of Lowest Temperature	22d	11th 20th	20th	14th	2d	9th 30th	1st	----	23d 24th	31st	29th	7th
Range of Temperature	66.0	62.0	6.0	6 >	52.0	47.0	47.0	----	46.5	48 5	47.	60.
Mean Daily Range of Temp	16.1	20.1	17.0	20.3	21.1	23.8	23.2	----	22.1	19.0	13.7	14.9
Number of Clear Days	13	11	9	10	9	17	24	----	18	12	11	5
Number of Fair Days	5	7	10	13	16	10	7	----	2	8	5	7
Number of Cl'dy Days	13	10	12	7	6	3	0	----	5	11	14	19
Number of Days Rain Fell	14	14	10	7	9	11	10	----	3	9	5	10
Total Rainfall for the Month	4.15	2.80	.45	2.95	3.11	4.06	3.90	----	2.58	3.48	2.90	2.10
Prevailing Direction of Wind	W	SW	W	W	W	W	W	----	W	W	W	W

SUMMARY FOR THE YEAR 1886.

	Jan.	Feb.	Mar	Apr.*	May	Jun.	July†	Aug	Sept	Oct.	Nov	Dec
Mean Relative Humidity	91.7	88.1	88.5	85.5	75.0	----	----	89.0	73.0	----	----	----
Mean Temperature	23.5	26.8	38.4	48.9	63.7	----	----	69.8	65.0	----	----	----
Highest Temperature	53.0	58.0	74.0	79.0	84.5	----	92.	89.0	90.5	----	----	----
Date of Highest Temperature	4th	11th	19th	15th	22d 30th	----	29th	11th	9th	----	----	---
Lowest Temperature	-11	-10.	8.	21.	37.5	----	50.3	44.0	37.0	----	----	----
Date of Lowest Temperature	11th	5th	22d	8th	17th	----	21st	4th	21st	----	----	----
Range of Temperature	64.0	68.0	66.0	58.0	47.0	----	41.7	45.0	53.5	----	----	----
Mean Daily Range of Temp	14.7	17.5	17.4	18.1	22.5	----	22.1	28.8	26.3	----	----	----
Number of Clear Days	5	8	6	4	14	----	10	11	13	----	----	----
Number of Fair Days	6	8	11	4	9	----	13	10	15	----	----	---
Number of Cl'dy Days	20	12	14	5	8	----	3	10	2	----	----	----
Number of Days Rain Fell	14	4	12	7	12	----	6	8	9	----	----	----
Total Rainfall for Month	5.72	.73	2.63	----	3.76	----	1.59	3.81	5.31	----	----	----
Prevailing Direction of Wind	W	SW	SW	W	S	----	NW	SW	NW	----	----	----

*The figures for April are from observations taken on the first seventeen days, except the 2d and 3d.

†Figures for July are from observations taken on all but first five days of month.

*SUMMARY FOR THE YEAR 1889.

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.
Mean Barometer	30.06	30.18	29.99	30.02	29.96	30.01	29.97	30.09	30.04	30.11	30.09
Highest Barometer	30.53	30.81	30.44	30.54	30.26	30.40	30.26	30.25	30.37	30.39	30.65
Date	19th	23d	30th	7th	5th	24th	6th	27th	27th	23d	16th
Lowest Barometer	29.23	29.49	29.61	29.54	29.62	29.72	29.67	29.73	29.54	29.73	29.49
Date	27th	4th	7th	28th	30th	18th	19th	14th	20th	25th	21st
Range of Barometer	1.297	1.326	.831	.995	.639	.686	.582	.518	.827	.660	1.154
Mean Relative Humidity	83.8	76.4	71.3	67.4	69.2	80.4	76.7	69.1	77.9	74.2	83.1
Mean Temperature	32.3	24.8	40.5	50.0	59.3	65.9	72.3	69.3	62.3	47.5	39.8
Highest Temperature	55.0	59.5	72.0	79.0	89.0	86.5	92.0	92.0	91.5	76.5	66.0
Date	17th	17th	17th	19th	10th	30th	9th	31st	1st	11th	1st
Lowest Temperature	14.0	-1.0	18.0	19.0	34.5	40.5	53.0	49.5	36.0	27.0	18.0
Date	22d	23d 24th	9th 30th	6th	1st	1st	16th	16th	1st 2d	24th	29th
Range of Temperature	41.0	60.5	54.0	60.0	54.5	46.0	39.0	42.5	55.5	49.5	48.0
Mean Daily Range of Temp	13.5	15.6	19.2	21.1	21.1	17.5	20.2	23.9	19.9	17.1	14.1
Number of Clear Days	7	5	9	10	9	5	12	20	10	12	3
Number of Fair Days	9	9	7	10	15	11	13	5	10	5	7
Number of Cl'dy Days	15	14	15	10	17	14	6	6	10	14	20
Number of Days Rain Fell	11	9	8	7	12	13	7	4	6	6	13
Total Rainfall for Month	3.79	1.25	1.07	1.43	2.90	3.30	3.76	0.73	3.91	2.23	4.50
Prevailing wind	SW	SW	NW	N	SW	SW	NW	NW	SE	NW	W

*No observations were made at Granville from October, '86, to December 1, '88. Then the Denison University Scientific Association obtained an observer to work under the Ohio Meteorological Bureau. Weather and wind observations were begun December 1, and the reading of the instruments December 11, 1888.

No observations were made in December, 1889.

SUMMARY FOR THE YEAR 1890.

	Jan.	Feb.	Mar.	Apr	May.	June	July.	Aug.	Sept.	Nov.	Dec.
	*		†	‡		⁂			‖		¶
Mean Barometer	30.18	30.09	30.24	----	29.92	29.92	----	30.05	30.01	30.05	----
Highest Barometer	30.68	30.49	30.49	----	30.26	30.29	30.25	30.29	30.34	30.30	----
Date	22d 28th	9th	8th	----	11th	8th	21st	23d	28th	11th	----
Lowest Barometer	29.82	29.49	29.99	----	29.59	29.86	29.68	29.70	29.87	29.73	----
Date	26th	14th	11th	----	5th	22d	2d	26th	13th	17th	----
Range of Barometer	.86	1.003	.50	----	.665	.43	.571	.583	.468	.57	----
Mean Relative Humidity	85.2	85.9	90.4	----	80.5	71.9	----	.764	82.2	73.7	88.23
Mean Temperature	37.3	39.2	28.7	----	59.0	73.0	----	67.7	61.6	43.5	27.27
Highest Temperature	66.0	65	60.0	----	86.	92.9	92.7	93.9	85.8	69.0	49.0
Date	13th	4th	11th	----	30th	30th	31st	3d	6th 7th	7th .7th	11th
Lowest Temperature	6	14.9	6.0	----	32.2	49.0	47.9	44.4	37.0	23.0	7.0
Date	22d	9th	7th	----	2d	7th	21st	23d	28th	26th 27th	9th
Range of Temperature	60.0	50.1	54.0	----	53.8	43.9	44.8	49.5	48.8	46.0	42.0
Mean Daily Range of Temp	17.4	17.9	15.7	----	19.5	21.7	23.3	20.4	20.5	21.2	17.8
Number of Clear Days	2	5	3	----	1	4	20	11	9	11	11
Number of Fair Days	9	5	3	----	18	13	7	13	13	8	8
Number of Cl'dy Days	15	18	9	----	12	3	4	7	6	9	1
Number of Days Rain Fell	12	8	6	----	10	5	7	11	11	3	3
Total Rainfall for Month	.049	6.36	1.83	----	3.36	2.43	2.03	4.48	7.33	1.91	1.16
Prevailing wind	S	W	N	----	S	S	SW	N	SW	SW	W

*Mean all but first 4 days. †Mean first 15 days. ‡No observations in April and October. ⁂No observations June 12–21. ‖Mean of 28 days. ¶Mean of first 20 days.

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BULLETIN

OF THE

Scientific Laboratories

OF

Compliments of

W. G. TIGHT.

EDITED BY

W. G. TIGHT, M. S.,

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

GRANVILLE, OHIO, JANUARY, 1892.

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VOL. VI. PART II.

WITH FIVE PLATES.

EDITED BY

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DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

GRANVILLE, OHIO, JANUARY, 1892.

NOTES UPON THE CLADOCERA, COPEPODA, OSTRACODA AND ROTIFERA OF CINCINNATI, WITH DESCRIPTIONS OF NEW SPECIES.

By C. H. Turner.

[Plates I–II.]

This paper does not pretend to be a monograph of the Rotifera and Micro-crustacea of this locality. It is but the embodiment of the results of a three months' study of the Micro-crustacea and the Rotifera of Cincinnati, Ohio, and the neighboring country. It is not probable that all the species of this locality have been encountered. No doubt many interesting forms await the discriminating gaze of the patient investigator. Yet, it is hoped that the present paper will give a fair idea of the micro-carcinological and of the rotiferon fauna of this neighborhood.

In a paper of such modest pretentions, it is not deemed necessary to re-describe well known species. Nor is it thought wise to give the complete bibliography of each species. Therefore, the author has contented himself with appending to each known species only such facts as may prove of interest to other workers in this line; and to referring to one or two standard works, in which a complete description will be found.

In this connection, I gratefully express my indebtedness to Professor C. L. Herrick, who kindly placed at my service his extensive collection of papers upon this subject. Without such literary aid this paper would not have been attempted.

PART I, ROTIFERA.

The arrangement of this portion of this paper is the same as that followed by Messrs. Hudson and Gosse, in their monograph upon "The Rotifera, or Wheel-animalcules, Both British and Foreign." London: Longmans, Green & Co., 1889.

ORDER I, RHIZOTA.

Family FLOSCULARIDAE.

I Genus Floscularia, Oken.

Sp. 1. *Floscularia ornata,* Ehrenberg.

Floscularia ornata, Hudson and Gosse. The Rotifera, or Wheel-animalcules, Vol. I, p. 50; pl. I, fig. 9.

Floscularia ornata, C. L. Herrick, Bull. of Sci. Lab. of Denison Univ., Vol. I, p. 47.

This species is not very abundant in this locality. It is occasionally found attached to the roots of the duck weed (*Lemnacea polyrrhiza, L.*)

ORDER II. BDELLOIDA.

Family PHILODINADAE.

II Genus Philodina, Ehrenberg.

Sp. 2. *Philodina roseola,* Ehrenberg.

Philodina roseola, Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. I, p. 99; pl. IX, fig. 4.

This species is abundant in all of our pools that contain water plants. Occasionally it adopts unique habitations. I have often found one or more of them inhabiting the cast off shells of some cladocera.

Sp. 3. *Philodina megalotrocha,* Ehrenberg.

Philodina negalotrocha, * * * Hudson & Gosse, The Rotifera, or Wheel-animalcules, Vol. I, p. 101; pl. IX, fig. 7.

This species appear to be quite rare. I have encountered it but once. Then it was found among a mass of filamentous algae which had been gathered from a shallow meadow pool. There it was quite abundant.

III. Genus Rotifer, Schrank.

Sp. 4. *Rotifer vulgaris,* Shrank.

Rotifer vulgaris, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. I, p. 104; pl. X, fig. 2.

This species inhabits a few of our stagnant ponds. It is found in company with *Cyclops viridis,* Jurine, naiad worms and other filth-loving creatures.

ORDER III. PLOIMA.

Sub-order. IL-LORICATA.

Family. ASPLANCHNADAE.

IV. Genus Asplanchna, Gosse.

Sp. 5. *Asplanchna cincinnatiensis, sp. n.*

[Plate I; Fig. 4, 5.]

To the naked eye this beautifully transparent specimen resembles a miniature sea-urchin.

Body of female saccate, free from humps, widest caudad of the middle. The eye is single, cervical. When viewed by transmitted light, the eye appears to be dark brown or black. Trophi incudate, not enclosed in a mastax. Rami pointed, extremity unnotched, unserrated. About half way between the distal and the proximal extremity of each ramus a large tooth projects entad. In the adult female the trophi, when at rest, are usually lateral and situated in the cervical region. In the young they are usually median. Flocculent ribbon double, the laterad portion is convoluted at its two extremities; while the mesad portion is straight and bears about fifteen vibratile tags. Gastric glands oval. These animals often contain several embryos at the same time. The nearest ally to this species is *A. brightwellii*, Gosse; from this our specimen is readily distinguished by the pointed, unnotched rami

Habitat: clear stagnant water, containing plant life. This species is not widely distributed but is very abundant where it does occur. Either this or a closely allied species has been encounted in clear stagnant pools that do not contain water plants. Length about 1 m.m.

The Brachionidae and allied forms appear to form the chief food of this species. I have seen individuals with the remains of two brachioni (*Brachionis urceolaris*, Ehrenberg), in its stomach at the same time. On another occasion I saw them gorged with the remains of *Anuraea cochlearis*, Gosse.

Sub-order. LORICATA.

Family. RATTULIDAE.

V. Genus Mastigocerca, Gosse.

Sp. 6. *Mastigocerca rattus*, Ehrenberg.

Mastigocerca rattus, * * * Hudson and Gosse, The Rotifera or Wheel-animalcules: Vol. II, p. 62; pl. XX, fig. 9.

Monocerca rattus, * * * C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 51.

This species is not widely distributed but is abundant among the roots of the duckweeds (*Lemnacea polyrrhiza*, L.) of a few of our ponds and canal basins.

VI. Genus Rattulus, Ehrenberg.

Sp. 7. *Rattulus tigris,* Mueller.

Rattulus tigris, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 65; pl. XX, fig. 13.

Diurella tigris, * * * C. L. Herrick, Bull. Sci. Lab. Denison Univ., Vol. I, p. 49.

This species is very abundant in our weedy canal basins.

Family DINOCHARIDAE.

VII. Genus Scaridium, Ehrenberg.

Sp. 8. *Scaridium longicaudum,* Ehrenberg.

Scaridium longicaudum, * * * Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 65; pl. XXI, fig. 13.

Although not widely distributed, this species is quite abundant among the roots of the duckweed (*Lemnacea polyrrhiza*, L.) in the few ponds and canal basins where it does occur.

Family SALPINADAE.

VIII. Genus Salpina, Ehrenberg.

Sp. 9. *Salpina mucronata,* Ehrenberg.

Salpina mucronata, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 83; pl. XXII, fig. 1.

This species is found in all of our weedy pools.

Sp. 10. *Salpina brevispina,* Ehrenberg.

Salpina brevispina, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 65; pl. XXII, fig. 4.

This is covered with impressed dots as described by Hudson and Gosse. This species is not so abundant as S. mucronata.

Family EUCHLANIDAE.

IX. Genus Euchlanis, Ehrenberg.

Sp. 11. *Euchlanis dilitata,* Ehrenberg.

Euchlanis dilitata, * * * Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 90; pl. XXIII, fig. 5.

Euchlanis (dilitata) hipposideros, * * * C. L. Herrick, Bull. Sci. Lab. Denison Univ., Vol. I, p. 47; pl. III, fig. 2.

This is very abundant in those ponds that contain *Lemnacea polyrrhiza*, L.

Sp. 12. *Euchlanis triquetra,* Ehrenberg.

Eucelanis triquetra, * * * Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 91; pl. XXIII, fig. 4.

This species is not common.

Family CATHYPNAIDAE.

X. Genus Cathypna, Gosse.

Sp. 13. *Cathypna ohioensis,* Herrick.

Distyla ohioensis, * * * C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 54; pl. XII, fig. 1.

This species is not common. It has been encountered once or twice in our canal basins.

Sp. 14. *Cathypna leontina,* sp. n

[Plate I; Fig. 12.]

Lorica smooth, sub-ellipsoidal, cephalad margin excavated. Dorsal valve larger than the ventral. Caudad margin of the dorsal valve furnished with a projecting plate. Eyes ellipsoidal. Toes two, rod-like. Near the distal extremity of each toe, there is a small lateral tooth. From this tooth the toe slopes obliquely to a terminal point.

There is a deep lateral invagination and the animal has the habit of retaining its head within the lorica; these two traits render this species a Cathypna and not a Distyla. This species is separated from *Cathypna ohioensis*, Herrick, its nearest ally, by the smooth lorica and the structure of the toe.

This species is very rare. So far it has been encountered in but one small, weedy pool. Even there it is only occasionally seen.

XI. Genus Monostyla, Ehrenberg.

Sp. 15. *Monostyla lunaris,* Ehrenberg.

Monostyla lunaris, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 98; pl. XXV, fig. 2.

This species is not common. Occasionally, it is found in our weedy pools.

Sp. 16. *Monostyla quadridentata,* Ebrenberg.

[Plate I; Fig. 10.]

Monostyla quadridentata, * * * Hudson and Gosse, The Rotifera or Wheel animalcules, Vol. II, p. 100; pl. XXV, fig. 3.

Monostyla quadridentata, * * * C. L. Herrick, Bull. Sci. Lab. Denison Univ., Vol. I, p. 53; pl. IV, fig. 3.

This species is abundant in all of our fresh water ponds.

Sp. 17. *Monostyla truncata,* sp. n.

[Plate I; Fig. 11.]

Lorica subovate, cephalad margin truncate, straight, caudad margin convex. Eye single, median, near the mastax. Mastax large, trophi sub-malleate. Foot moderate, non-contractile, terminating in a single toe.

In the specimen examined, the cephalad extremity of the body appeared to be bifurcate; this may have been an illusion due to the point of view.

This species is very rare. I have seen only one specimen. The truncated cephalad margin of the lorica serves to distinguish this species from all others.

Family COLURIDAE.

XII. Genus Metopidia, Ehrenberg.

Sp. 18. *Metopidea, bractea,* Ehrenberg.

Metopidia bractea, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 109,

Squamella bractea, * * * C. L. Herrick, Bull Sci. Lab. of Denison Univ., Vol I, p. 54; pl. IV, fig 2.

This species is not abundant.

Sp 19. *Metopidia elliptica,* sp. n.

[Plate I; Fig. 8.]

Lorica smooth, sub-elliptical, about twice as long as broad. Caudad margin of ventral valve excavated. From the cephalad extremity of the body, two small, but conspicuous, lateral ears project. Joints of the foot sub-equal. The two terminal toes pointed, and as long as the remainder of the foot.

This species is not common. It is occasionally encountered in pools covered with monocellular algae.

Sp. 20. *Metopidia dentata*, sp. n.

[Plate I; Fig. 9.]

In the shape of the lorica, this species resembles *M. elliptica.*

Lorica smooth sub-elliptical, cephalad margin excavated. From the bottom of the cephalad excavation of the ventral portion of the lorica, a convex tongue projects half way to the cephalad extremity of the lorica. Caudad margin of the ventral valve excavated. The distal joint of the foot about as long as the combined length of the other two. The terminal toes are about as long as the distal joint of the foot. At the base each toe is supplied with a small, sharp, lateral spine.

Length of lorica about 104 micro-millimetres; breadth, about 65 micro-millimetres.

This species is very rare. Having seen it but once, I do not put much stress upon the convex tongue seen upon the cephalad portion of the ventral valve. I fear that that may be only a chance variation. But the relative lengths of the joints of the feet, the relative length of the toes, the spines at the base of the toes—all these are characters which distinguish it from *M. elliptica*, its nearest ally.

Family PTERODINADAE.

XIII. Genus Pterodina, Ehrenberg.

Sp. 21. *Pterodina patina,* Ehrenberg.

Pterodina patina, * * * Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 112; pl. XXVI. fig. 11.

Pterodina patina, * * * C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 59; pl. I, fig. 3.

This species is very abundant around the roots of the duckweeds (*Lemnacea polyrrhiza*, L.) of our larger ponds and canal basins.

Family BRACHIONIDAE.

XIV. Genus Brachionus, Ehrenberg.

Sp. 22. *Brachionus pala,* Ehrenberg

Brachionus pala, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules; Vol. II, p. 117; pl. XXVII. fig. 3; and pl. XXVIII, fig. 3.

This species is occasionally encountered in one or two of our shallow meadow pools. The specimens encountered so far resemble

what Ehrenberg has called *Brachionus ampiceros*. Hudson and Gosse consider this to be a variety of *B. pala*.

Sp. 23. *Brachionus urceolaris*, Ehrenberg.

Brachiomus urceolaris, * * * Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 118; pl. XXVII, fig. 6.

It is not easy to decide whether the species here described is *B. urceolaris* or *B. rubens*. After some hesitation I have considered it to be the former. I append a description:

Lorica sub-quadrangular, longer than broad. Cephalo-dorsad margin of the lorica bearing six straight teeth Lateral teeth largest, Middle pair next in size. None of the teeth very large, the lateral teeth, however, are relatively larger than the corresponding teeth of the British species. Between the middle teeth there is a shallow, concave, depression. From the base of the tooth to the bottom of this depression is about as long as the height of the tooth. Cephalo ventrad margin of the lorica slightly elevated and indented at the meson. Laterad margin of lorica straight, caudad margin convex. No caudal spines. A sub-square orifice in the middle of the caudo-ventrad margin of the lorica serves for the exit of the very flexible, wrinkled, foot. This orifice is bordered by two lateral papillae.

This species is often encountered in ponds containing plant life. Either this or a closely allied species is often found attached to the lorica of *Moina paradoxa*, Weismann.

Sp. 24. *Brachionus bakeri*, Ehrenberg.

[Plate I; Figs. 1-3.]

Brachionus bakeri, * * * Hudson and Gosse. The Rotifera, or Wheel-animalcules; Vol. II, p. 120; pl. XXVII. fig. 8.

Brachionus bakeri, * * * C. L. Herrick, Bull. Sci Lab. of Denison Univ., Vol, I, p. 55.

This is the commonest of our Brachionidae and it is subject to great variations, not only in appearance but also in size. Some varieties appear to be fully one-third again as large as others.

The markings upon the loriea vary in different individuals. In some cases the lorica is smooth, while in others it is more or less facetted and granulated.

The shape of the depression between the middle teeth of the cephalo-dorsad margin of the lorica also varies. In some individuals this depression is acute, while in others it is strongly convex.

This species is found in ponds containing plant life. Sessile vorticellidae are often found attached to the lorica of this species. Sometimes they are situated at the cephalad extremity of the lorica, evidently appropriating a portion of the food attracted by the cilia of the Brachionus; while in other cases these vorticellidae are attached to other parts of the lorica.

Sp. 25. *Brachionus militaris,* Ehrenberg.

Brachionus militaris, * * * Hudson and Gosse, The Rotifera or Wheel-animalcules; sup., p. 52; pl. XXXIV, fig. 23.

Brachionus militaris, * * * C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 56; pl. X, fig. 10.

During mid summer this species was abundant in all of our weedy pools. It seems to be fond of wallowing in the debris that is found at the bottom of such pools.

Sp. 25. *Brachionus tuberculus,* sp. n.

[Plate 1; Fig. 6.]

Lorica sub-rectangular, slightly wider than long (spines excluded), warted. The cephalo-dorsad margin is supplied with six teeth. The middle teeth are much larger than any of the others. Next in size come the lateral teeth. Between the two middle teeth there is a narrow, concave excavation. The cephalo-ventrad margin of the lorica is feebly convex. This margin is supplied with four small, sub-equal crenations. Two of these are situated, one near each lateral surface of the lorica; the remaining two are located near the meson. Between the two sub-median crenations there is a shallow concave excavation. The laterad margins of the lorica are convex. The caudad margin is straight. At its corners it is supplied with two long spines; these spines are more than half the length of the body of the lorica. The orifice for the protrusion of the foot is guarded by two small, unequal spines.

The whole lorica is densely covered with small tubercles, hence the name. These tubercles are found even upon the larger teeth of the cephalad margin and upon the spines. In a few individuals the spines appeared to be unwarted. The foot is very flexible.

During mid-summer this species was very abundant around the roots of the duckweeds (*Lemnacea polyrrhiza*, L.), of one of our larger ponds.

FAMILY ANURAEADAE.

XV. GENUS ANURAEA, Gosse, nec Ehrenberg.

Sp. 27. *Anuraea tecta,* Gosse.

Anuraea tecta, * * * Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 123; pl. XXIX, fig. 10.

During the latter part of summer a single individual of this species was encountered in one of our shallow, weedy ponds.

Sp. 28. *Anuraea cochlearis,* Gosse.

[Plate I; Fig. 7.]

Anuraea cochlearis. * * * Hudson and Gosse, the Rotifera or Wheel-animalcules; Vol. II, p. 124; pl. XXIX, fig. 7.

Myriads of this species have been encountered in one of our clear ponds. Here, as in England, they are much preyed upon by Asplanchnas.

PART II. CRUSTACEA.

The arrangement adopted in this portion of this paper is the same as that followed by Professor C. L. Herrick, in his "Final Report Report upon the Crustacea of Minnesota."

ORDER CLADOCERA.

FAMILY SIDIDAE.

I. GENUS SIDA, Straus.

Sp. 1. *Sida crystallina,* Mueller.

Sida crystallina, * * * C. L. Herrick, Final Report on Minnesota Crustacea, p. 20.

This beautiful species appears to be quite rare in this locality. I have seen it but once. On the 17th of April, 1891, several were found among the Sagittaria in one of our canal basins.

FAMILY DAPHNIDAE.

II. GENUS MOINA, Baird.

Sp. 2. *Moina paradoxa,* Weismann.

Moina paradoxa, * * * C. L. Herrick, Final Report on Minnesota Crustacea, p. 34; pl. A, figs: 1, 3, 6, 7, 9.

During the latter part of summer and the early part of fall, this species was very abundant in several of the stagnant pools that

occupy the bottom lands upon either side of the Ohio River. Ephippial females appear about the middle of September.

A certain species of Brachionus—probably *Brachionus urceolaris*, Weismann—is often found attached to this animal.

III. Genus Scapholeberis.

Sp. 3. *Scapholeberis mucronata*, Mueller.

Scapholeberis mucronata. * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 42; pl. J, fig. 5.

This species is abundant in all of our ponds.

The brood cavity usually contains two embryos, each of which is about as long as that cavity. The head of one embryo is directed caudad, while the head of the other is directed cephalad.

Ephippial females appear about the latter part of September.

IV. Genus Simocephalus.

Sp. 4. *Simocephalus vetulus*, Mueller.

Simocephalus vetulus, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 46.

This species is abundant in all of our canal basins and in many of the ponds that contain plant life. It varies in hue from almost colorless to a brick red.

V. Genus Daphnia.

Sp. 5. *Daphnia pulex*, Mueller.

Daphnia pulex, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 56.

This species is very abundant and is found in the same situations as *Moina paradoxa*, Weismann. They are fond of foul water and a dump pond is sure to be filled with them. The body is often covered with Vorticellidae and other Infusorians.

Ephippial females appear about the middle of September.

Family LYCEIDAE.

Sub-family LYCEINAE.

VI. Genus Lynceus.

Sub-genus Alona.

Sp. 6. *Alona porrecta*, Birge.

Alona porrecta, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 99.

Although not abundant, this species has been encountered several times.

Sp. 7. *Alona glacialis,* Birge.

Alona glacialis, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 100.

This species is very scarce.

Sp. 8. *Alona intermedia,* Sars.

Alona intermedia, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 101; pl. I, fig. 15.

Sub-genus Pleuroxus.

Sp. 9. *Pleuroxus denticulatus,* Birge.

Pleuroxus denticulatus, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 110; pl. G, figs. 12, 13.

This species is abundant in all of our canal basins and in several of the larger ponds.

The number of teeth upon the caudo-ventrad angle of the shell varies from one to three.

Sp. 10. *Pleuroxus hamatus,* Birge.

Pleuroxus hamatus, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 110; pl. II, fig. 1.

Although not widely distributed, this species is quite abundant in the few canal basins and large ponds where it does occur.

A few slight deviations from the descriptions that I have seen of this species tempt me to give a complete description. I have not seen Professor Birge's description. Shell long and low, about twice as long as high. Length about 478 micro-millimetres, height about 278 micro-millimetres. Caudad margin of shell straight, about two-thirds as high as the greatest height of the shell. Caudo-ventrad angle of shell not toothed, but is margined with minute sharp points. Ventrad margin straight or feebly concave, supplied with a fringe of long hairs. Beak curved caudad, about twice as long as the antennules, including hairs. Shell is coarsely marked with the same lines that adorn the shell of *P. denticulatus.* In addition, the whole shell is closely striated with fine, undulating, sub-parallel, longitudinal, lines. These striations extend out upon the beak. Eye larger that the pigment fleck. First foot of the female supplied with a claw. The post-abdomen is long, slender, truncated.

Its caudad border is supplied with a row of sharp teeth. The distal teeth are the longest, thence they gradually decrease in length. The terminal claw of the post abdomen is supplied with two short basal spines.

VII. Genus Chydorus, Leach.

Sp. 11. *Chydorus sphaericus*, Mueller.

Chydorus sphaericus. * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 116, pl. F, figs. 4, 7, 8, 10.

This species is very abundant in shallow, weedy, pools.

ORDER COPEPODA.

Family CALANIDAE.

VIII. Genus Diaptomus, Westwood.

Sp. 12. *Diaptomus pallidus*, Herrick.

Diaptomus pallidus, * * * C. L. Herrick Final Report on Minn. Crustacea, p. 142; pl. Q. fig. 17.

This species is quite abundant in two or three of our shallow ponds. Its transparency renders its detection difficult.

IX. Genus Cyclops, Mueller.

(*Antennae 17-jointed.*)

Sp. 13. *Cyclops ater*, Herrick.

Cyclops ater, * * * C. L. Herrick. Final Report on Minn. Crustacea, p. 145; pl. Q2, figs. 9-12.

Cyclops ater, * * * C. L. Herrick, Crustacea of Alabama, p. 14.

This species is occasionally encountered in the larger canal basins.

Sp. 14. *Cyclops viridis*, Jurine.

Cyclops viridis, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 145.

This species is found in all of our waters. It is especially abundant in stagnant water. Occasionally this animal is colorless, but usually it is rendered green by myriads of green infusoria which attach themselves to its body. Occasionally species of Vorticellidae are seen attached to its body.

Sp. 15. *Cyclops parcus*, Herrick.

Cyclops parcus, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 145.

This species is frequently found in our canal basins.

Sp 16. *Cyclops tenuicornis,* Claus.

Cyclops signatus, * * * G. S. Brady, British Copepoda, Vol. I, p. 100; pl. XVII, figs. 4-12.

Cyclops tenuicornis, * * * G. S. Brady, British Copepoda, Vol. I, p. 102; pl. XVIII, figs. 1-10.

Cyclops tenuicornis, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 153. pl. R fig. 16

This species is very abundant in many of our ponds and canal basins. Here we have two distinct varieties. In one variety the knife-edge upon the distal joint of the antennae is smooth, in the other it is toothed. This second variety might, with propriety, be divided into two sub-varieties. In one, the usual case, the teeth upon the knife-edge are small triangles; in the other they are stout hooks. The case where the teeth are small triangles corresponds to *C. signatus*, Koch.

(*Antennae 12-jointed.*)

Sp. 17. *Cyclops serrulatus,* Fischer.

Cyclops serrulatus. * * * G. S. Brady, British Copepoda, Vol. I, p. 109; pl. XXII, figs. 1-14.

Cyclops serrulatus, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 157; pl. O, figs. 17-19.

This species is common in all of our weedy ponds.

Sp. 18. *Cyclops fluviatilis,* Herrick.

Cyclops fluviatilis, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 159; pl, Q5, figs. 1-9.

Cyclops fluviatilis, * * * C. L. Herrick, Alabama Crustacea, p. 15.

Although not widely distributed, yet this form is very abundant in the few peaty pools where it does occur.

(*Antennae 11-jointed.*)

Sp. 19. *Cyclops phaleratus,* Koch.

Cyclops phaleratus, * * * G. S. Brady, British Copepoda, Vol. I, p. 116; pl. XXIII, figs. 7-13

Cyclops phaleratus, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 161; pl. R, figs. 6-10.

This species is rare.

(*Antennae 8-jointed.*)

Sp. 20. *Cyclops fimbriatus,* Fischer.

Cyclops crassicornis, * * * G. S. Brady, British Copepoda, Vol. I, p. 118; pl. XXIII, figs. 1-6.

Cyclops fimbriatus, * * * C. L. Herrick, Final Report on Minn. Crustacea, p. 162, pl. R, fig. 11.

This species is abundant in all of our pools. It varies in color from a faint pinkish hue to a brick red.

ORDER OSTRACODA.

X. Genus Cypris, Mueller.

Sp. 21. *Cypris virens,* Mueller.

Cyyris virens, * * * G. S. Brady, Recent British Ostracoda, p. 364, pl. XXIII, figs. 23-32; pl. XXXVI, fig. 1.

Cypris virens, * * * Brady and Norman, Ostracoda of North Atlantic and Northwest Europe, part I, p. 74.

Cypris virens, * * * C. L. Herrick, Alabama Crustacea, p. 24; pl. VI, fig. 3.

This species is abundant in our shallow, grassy ponds.

Sp. 22. *Cypris sp* (?)

[Plate II; Figs. 11-13.]

Although agreeing in many particulars with *C. virens*, Jurine, this species differs from it in the following respects:

1. The caudad half of each valve is marked with a series of concentric lines which in appearance resemble a nest of test tubes that has been bent into the shape of a retort.

2. The ventrad border of each valve is fringed with a row of tubercles. Each tubercle terminates in a hair. (Some specimens of C. virens are said to possess this feature.)

3. The caudad margin of the post abdomen is smooth.

During the summer this species was very abundant in several of our shallow, weedy pools. Among dozens examined no females were encountered. It will be noted that its habitat is the same as that of *C. virens.* It is possible that it is the male of that species.

Sp. 23. *Cypris herricki,* sp. n.

[Plate II: Figs. 1-10.]

In a lateral view, the shell is sub-triangular, highest near the middle. The ventral margin is straight, excepting at its cephalad

extremity, where, after a shallow concave notch, the margin is convex. The remainder or the margin is strongly convex. From the above described ventral notch, a well defined, feebly convex, line passes dorsad to the opposite margin. That portion of the shell which lies cephalad of this line is usually curved laterad. From within the cephalad and caudad extremities of the valves numerous hairs protrude.

In a dorsal view, the shell is sub-fusiform, being widest caudad of the middle. At their caudad extremity the valves are slightly divaricated, while at their cephalad extremity they are closely approximated. The shell is covered with fine reticulations and minute hairs. In addition to these, it is marked with conspicuous dark green bands. These bands are arranged as follows: One, parallel to and almost adjacent to the mesal border of the shell, extends from the caudo-ventrad angle of the shell dorso-cephalad almost to the cephalad extremity of the valve. There it divides. One portion continues in the same course to the cephalo-ventrad extremity of the valve. The other, turning laterad, passes ventrad for a short distance and terminates in a sharp point. At the origin of this line there is a large, convex blotch, which extends ventrad a short distance. Near the centre of the figure several bands fuse in such a manner as to form a hollow, sub-square figure. From the cephalo-dorsad corner of the square a tongue passes ventro-caudad into the square. The length of this tongue and the angles it makes with the sides of the square vary slightly in different individuals. Usually it extends almost to the centre. From this same angle of the shell a band projects ectad. After passing cephalad a short distance, this band forms a convex curve and passes caudo-dorsad almost to the margin of the shell. From the caudo-dorsad angle of the square a short band passes dorso-caudad and fuses with a broader band which passes caudad, approximately parallel to the dorsal margin of the shell. From this same corner another band passes caudo ventrad almost to the caudad margin of the shell. This band is approximately parallel to the band just described. From the caudo-ventrad angle of the square a band passes caudo-ventrad almost to the caudo-ventrad extremity of the shell. In the caudad portion of its course this band curves dorsad, otherwise it is approximately parallel to the band last described. From the cephalo-ventrad angle of the square, a short band projects ventrad and then broadening, forms a boot-shape band. The short heel of this boot projects caudad and

terminates in a point, the long toe extends cephalad and terminates bluntly. From the same corner of the square, a second band projects cephalad to about the level of the toe of the boot. There it fuses with a spike-shape band which extends cephalo-ventrad from near the cephalo-dorsad angle of the square to about the cephalo-ventrad extremity of the shell. The head of the spike is at the caudo-dorsad extremity of the band. The two bands fuse near the head.

The number of lucid spots is about eight. They are situated in the centre of the valve and ordinarily are enclosed within the square above described.

The sketches of the appendages are self-explanatory. However, I will call attention to two points:

1. The brush upon the second pair of antennae does not extend quite to the distal extremity of the terminal claws of the same.

2. At the base of the distal joint of the second foot we find two claws. The caudad claw is much the larger and is bordered with a row of small teeth.

Length of shell about 3 millimetres; height about 1 millimetres. Excepting *C. perelegans*, Herrick, this is believed to be the largest member of this genus yet discovered Its large size renders it an excellent subject for class work.

So far this species has been encountered in but one locality. In the shallow weedy tongue of one of our canal basins it is quite abundant.

XI. Genus Cypridopsis, Brady.

Sp. 24. *Cyprodopsis vidua,* Mueller.

Cypridopsis vidua, * * * G. S. Brady, Recent British Ostracoda, p. 375. pl. XXIV, fig. 27-36, 46.

Cypridopsis vidua, * * * Brady and Norman, Ostracoda of the North Atlantic and Northwestern Europe, part I, p. 89.

Cypridopsis vidua, * * * C. L. Herrick, Alabama Crustacea, p. 31; pl. IV, fig. 1.

This species is common in all our pools. *Variety Obesa* is occasionally seen.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Brachionus bakeri.* [Variety) Lorica, ventral view.

Fig. 2. do do Cephalo-dorsad margin of the lorica, one variety.

Fig. 3. *Brachionus bakeri.* Dorsal view.

Fig. 4. *Asplanchna cincinnatiensis.* The left focculent ribbon is not shown.

Fig. 6. *Brachionus tuberculus.* Lorica, ventral view.

Fig. 7. *Anuraea cochlearis.*

Fig. 8. *Metopidia elliptica.* Ventral view.

Fig. 9. *Metopidia dentata.* Lorica, with foot. Ventral view.

Fig. 10. *Monostyla quadridentata.*

Fig. 11. *Monostyla truncata.*

Fig. 12. *Cathypna leontina.* Ventral view. Lorica, with toes, trophi, and eye.

PLATE II.

Fig, 1. *Cypris Herricki. sp. n.,* lateral view.

Fig. 2. do do dorsal view.

Fig. 3. do do one of the first pair of antennae

Fig. 4. do do one of the second pair of antennae.

Fig. 5. do do mandible.

Fig. 6. do do first maxilla.

Fig. 7. do do second maxilla.

Fig. 8. do do first foot.

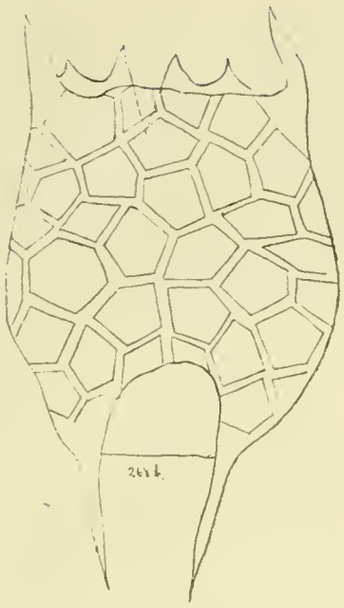
Fig 9. do do second foot.

Fig. 10. do do post abdomen.

Fig. 11. *Cypris sp.* (*?*) lateral view.

Fig. 12. do mandible.

Fig. 13. do feet.



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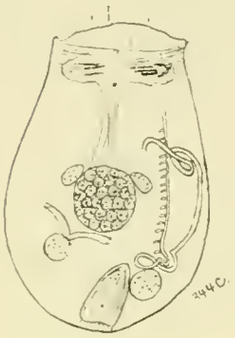

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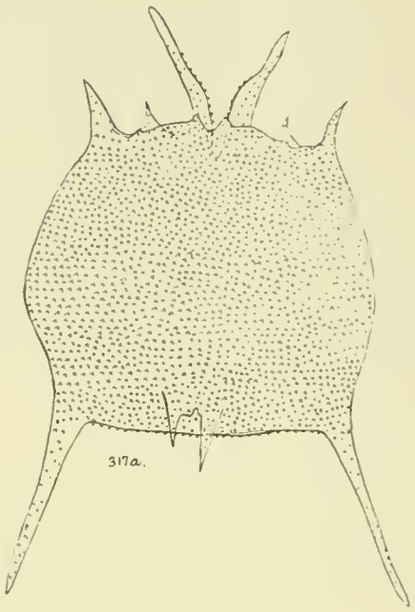

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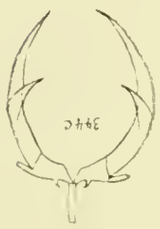

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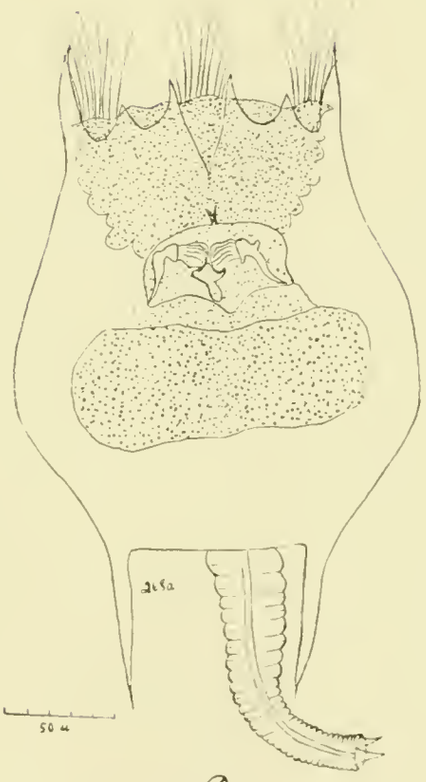

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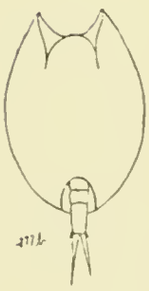

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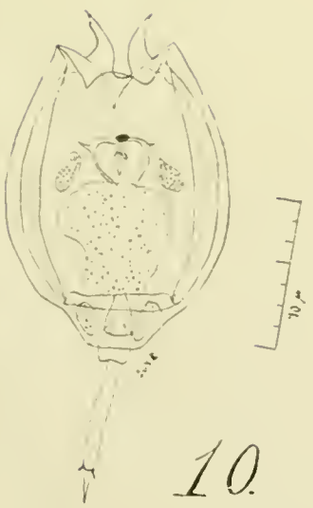

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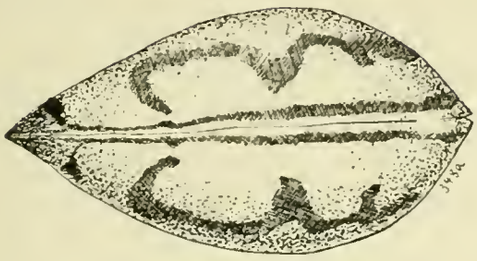

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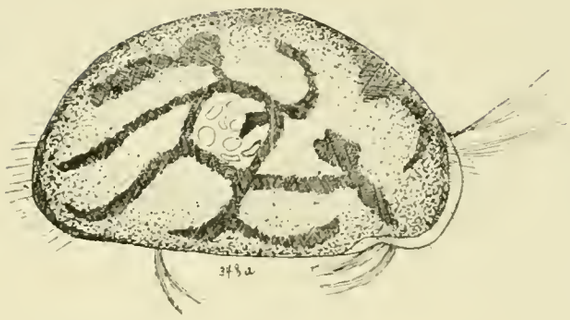

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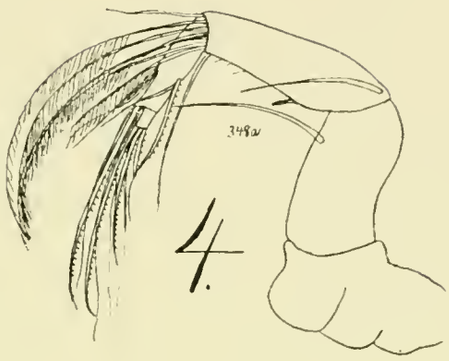

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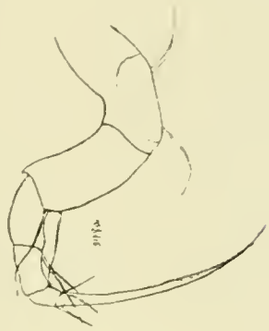

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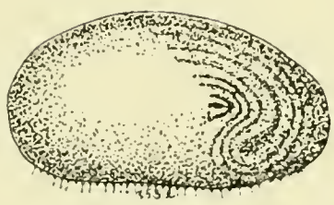

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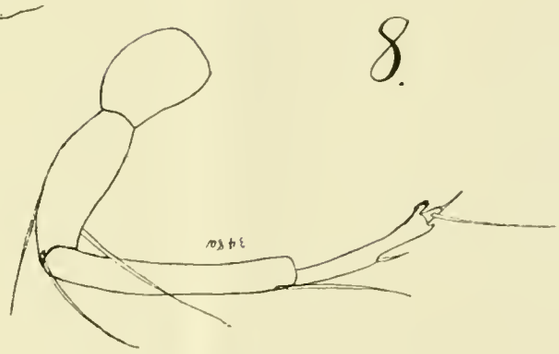

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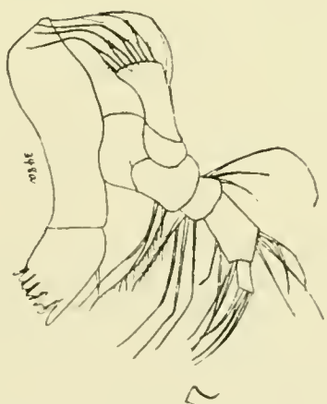

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THE CEREBRUM AND OLFACTORIES OF THE OPOSSUM, DIDELPHYS VIRGINICA.

By C. L. Herrick.

With Plates A. B. and C.

Material had been collected over a year ago for a study of the brain of the opossum, but, for various reasons, the completion of the paper was delayed until it now seems best to offer such notes as were collected upon the cerebrum in their necessarily incomplete form. This has seemed the more desirable in as much as this paper forms a portion of a series especially devoted to the histology of the gray matter and commissures of the cerebrum in the several groups of vertebrates and because it in a sense prepares the way for the delayed portion of the rodent paper begun in volume V of this bulletin.

External Form.

In most particulars the brain of the opossum resembles that of rodents, although the relative size of the cerebrum is less than in any rodent type. A larger part of quadrigemina is exposed and the proportions of the infra-rhinalis to the supra-rhinalis portion of the cerebrum is less. In one respect only does the opossum brain approach that of carnivora, i. e. in the possession of an apparent homologue of the crucial sulcus. But there is good reason to doubt the reliability of this homology

The olfactories are relatively very large and are obliquely attached to the crura. They contain, as shown beyond, a considerable mass of cortex upon the pes. Longitudinal sections show a strong medio-ventral fossa filled by a thickening of the pero, especially the glomerular layer. The cavity or rhinocœl is very large and connected with the lateral ventricle by an oval curved aqueductus cruris. The crura are large and exhibit a distinct radix lateralis.

The cerebrum is pyriform with the caudal portions of the hemispheres divaricated. The hemispheres may each be divided both morphologically and histologically into a dorsal and ventral portion sepa-

rated laterad by the rhinalis fissure and mesad by the splenialis. The portion dorsad of these almost continuous fissures may be regarded as the dorsal lamina or mantle par excellence, while that part beneath contains the ventral lamina and alae. A large part of the ventral portion is devoid of cortex in the usual sense. The dorsal surface is divided into a small frontal lobe, which is circumscribed very deeply from the rest, and a large ovate parieto-occipital portion, which is not subdivided.

The ventral portion is likewise divided into an anterior post-rhinal lobe occupying the region in front of the chiasm and fusing with the crus cephalad, and the large pyriform lobe with its modified cortex. The latter is expanded by the ventral part of the hippocampus into which it passes caudo-ventrad.

The sylvian fissure is not pronounced and does not extend across the rhinalis fissure. A slight longitudinal depression extends longitudinally of the pyriform. This marks the course of the olfactory fibres and limits the non-cortical from the cortical portion. All of the region ventrad is devoid of a genuine cortex. Dorsad of it, the surface is occupied by olfactory fibres as far as to the rhinalis fissure. The mesad surface is separated by the splenialis or calloso-marginal fissure into a dorsal and ventral portion, but this fissure is relatively farther dorsad than the rhinalis by reason of the interpenetration of the thalamus. Cephalad, the rhinalis and splenialis unite and cut off the projecting frontal lobe from the crus beneath.

There is a slight fissure where one might look for the callosal, but in the absence of that commissure it is but the union of the cortex of the gyrus fornicatus with the base. All beneath this fissure is devoid of true cortex and is continued caudad into the septum and corpus fornicis. (See Figs. 3 and 4, Plate A.) The splenialis grows deeper as it passes caudad, following the arch of the hemisphere until it lies in a dorso-ventral line. By comparing the longitudinal sections of Plate B with the transverse series of Plate A, the course of the fissure and the structure of the hippocampus will be perfectly obvious. The commissures are discussed beyond.

The thalamus is about as in rodents.

Minute Anatomy.

Rhinencephalon. The olfactory lobe, as a whole, is of relatively very large size, being expanded in all directions beyond the crus and especially produced cephalo-dorsad. No part of the dorsal part of the

pero or cap of the tuber is covered by the cerebrum. The lobe is much larger, for example, than the precrucial lobe of the hemisphere. As seen from above, the outline is ovoid with the larger end caudad and the longer axis passing obliquely caudo-ventrad. The ventral aspect is acutely ovate or subtriangular with the apex mesi-caudad. In its natural position, the infero-cephalic surface is curved and the greater portion is covered by the fibres of origin of the olfactory nerve.

The pero (as this term is used by Wilder) consists of a cap or buskin-like body which entirely clothes the lobe. Its substance extends nearly to the ventricle, which latter is, however, clothed with a larger or smaller mass of white matter with a gray envelope differing totally from that which pertains to the pero proper. Passing entad, we encounter successively the following layers. 1. The fibre layer, which consists of apparently irregularly disposed fibre clusters intercrossing confusedly. Among the fibres are numerous blood-vessels and the usual inoblasts and leucocytes accompany the fibres. 2. The glomerulary layer is of the usual structure; fibres from the cells next to be described pass into the dense ball of neuroglia and emerged clothed with their myelin as distinctive olfactory fibres. It is suggested that the glomerule is simply a locus devoted to the manufacture of the myelin sheaths of the nerves. In this case the only active agents in the process must be the large number of wandering cells or Deiter's corpuscles which congregate about the glomerules in large numbers. If the Deiter's cells have this function here it would be easy to predicate a similar function of the same cells elsewhere. There are many reasons for such an assumption in other parts of the brain. The presence of exactly similar cells in the tracts of medullated fascicles elsewhere is suggestive. (See also Flechsig's' works on the development of the sheaths.) The same explanation may be given for the exactly similar cells in the laminated granular layer. 3. The external neuroglia layer is in this case not distinct from the layer next entad, as the ganglionic layer is dispersed throughout them both. In this respect the opossum differs from any other mammal examined. The ganglion cells are perhaps most abundant near the external boundary of the laminated granular layer, but are irregularly distributed to the very base of the glomerulary layer. The ganglion cells are of pyramidal form and large size with a (generally single) strong apex process which can be traced as a large non-medullated fibre to the glomerulary layer. From the base several processes extend latero-entad or laterad

and after penetrating the layers of the granular zone their fibres continue toward the crus. It has not proven possible to determine whether the fibres anastamose and form a reticulum or whether there is one main branch and lateral nutrient roots as claimed in other cases. Our own impression is that there is considerable lateral anastamosis in the neuroglia layers and that fibres after passing into the granular layer soon again acquire medullary sheaths. If, as we believe, the ganglion cells are to be compared with the cells of the spinal ganglia, it would appear that this locus is a point where nourishment is received and hence the myelin sheaths must be interrupted. This space devoid of medullary sheaths is richly supplied with the Deiter's cells which convey the nourishment and also affords the opportunity for intercommunication. The ganglion cells are comparatively large and bear a close resemblance to those of fishes, for example. The nuclei seem to be normally ovoid; but the cells frequently shrink during preparation and this shrinkage especially affects the nucleus.

4. The granular layer is well developed and laminated, each lamina being separated by tracts accumulated from the entad processes of the ganglionic cells. The fibres near the tip seem to pass almost directly through this layer to accumulate at the ventricular surface where they have been considered as forming a part of the pes though actually belonging to the pero. Farther caudad the course of the fibres is oblique. Two different types of corpuscles may be distinguished in these granular laminæ, one being globular and rather larger than the ovoid and darker bodies which we have supposed might be those connected with the function of formation of sheaths for these fibres, while the former would retain the more purely nutritive function.

The pes. Cephalad the ventricular epithelium alone represents the core of the lobus olfactorius. The epithelium resembles that of other parts of the ventricular system. A few connective fibres extend into the granular layer and bear the usual dark inoblastic nuclei. Near the point where the lobe joints its crus the pes develops a different ental structure. Here there is an invasion of cortex from the cerebrum. These cells exhibit no orderly arrangement cephalad, but are irregularly disposed and are pyramidal and deeply staining. The area is triangular, being bounded caudad by the peculiar structure of the post-rhinal lobe, from which it is separated by a distinct fibre tract.

The greater part of this cortex pertains to the crus and may be there considered.

Crus olfactorius. The crus terminates in the pes obliquely, the lateral and dorsal portions being longest. Ventrally it is chiefly made up of the radices of tracts from the pero. There are three such fibre-bundles; the largest, or *radix pedis lateralis*, is an exceedingly strong band, as in rodents. Its development stands in direct proportion to that of the olfactory lobe and this, in turn, with that of the hippocampus. The fibres collect in the granular layer of the pero and then about the ventricle, accumulating chiefly mesad and ventrad. On entering the pes they encounter the invading cortex cruris and are driven ectad, thence laterad superficially to the cortex cruris, where they form a strong bundle passing caudad and somewhat laterad along the fissura radicis to the lobus pyriformis, thence for the most part to cross mesad and entad into the hippocampus, especially the fornicate gyrus. The tract of the fibres caudad is not compact but they spread out to some extent upon the pyriform. The fibres of this ectal olfactory tract are in part overlapped by fibres of a different character.

The *radix pedis mesalis*, on the other hand, is very small and disperse. Its fibres, which arise on the ventral and mesal, as well as especially in the meso-dorsal part of the crus, pass in the neuroglia layer and remain ectad to the cell zone until reaching the neighborhood of the splenialis fissure, where they cross to the gyrus fornicatus. The bundles do not unite to form a single tract but remain largely isolated from each other.

There is no external indication of a *radix pedis intermedius*, but we encounter a few bundles which apparently arise from the ventral part of the crus and passing caudad through the substance of the lobus post-rhinalis emerge mesad and ectad to unite with the bundles of the radix mesalis on their way to the gyrus fornicatus. The fibres enter the peduncular tracts in their dorsad course and pass through them. As indicated above, the dorsal, lateral and mesal aspects of the crus are covered by cortical masses.

Thus far we have been dealing with tracts which undoubtedly pertain to the olfactory pero or ganglion proper. Greater difficulty arises in construing the so called ental olfactory tract (radix mesalis of fishes.) Following suggestions arising from these studies, Mr. C. Judson Herrick has investigated the relations of the cortex cruris to the pero, in rodents. He arrives at the conclusion (Bul Denison

Univ., Vol. VI,) that there is no direct connection between the tractus præcommissuralis cruris, or internal olfactory tract, and the olfactory substance. On the other hand, the fibres of the tract seem to be largely derived from the cortex cruris and its forward extension into the pes. Of this relation we have been long convinced in the opossum, as well as lower vertebrates, though it would be premature to decide that there is no secondary connection with the pero. A few general considerations might be advanced to indicate the bearing of the conclusion suggested.

1. The olfactory, as a sensory nerve, should be derived from the dorsal part of the primitive medullary tube or embryonic vesicle. According to the above suggestions, such an origin is the only one. The three superficial radices ultimately reach the gyrus fornicatus. Now, if the callosum be considered the partial homologue of the dorsal commissure of the cord, of which there can be little doubt, the cephalic part of the hippocampus, i. e. gyrus fornicatus, is the homologue of the most dorsi-mesal part of the vesicle. The commissura fornicis is also a portion of the dorsal commissural system and the connected parts of the hippocampus are morphologically part of dorsi-meson. The enormous development of the parietal part of the first embryonic vesicle which serves to bring much of the ventral surface dorsad, especially cephalad, causes a revolution correlated with the flextures which obscure the primitive simplicity, but in the rodents and marsupials, it is nevertheless sufficiently obvious.

2. The olfactory, as a sensory nerve, should have a trophic ganglion. This might lie upon the nerve itself, occupying a distinct fossa in the skull, like the Gasserian; it might be carried peripherad and become associated with the end organ, as in the auditory; or it might fuse with the brain itself to form an apparently organic unity. To us the latter seems the actual state of the case. If the tracts are really superficial, lying, for the most part, ectad to the neuroglia layer and, in spite of subdividing into several bundles, reach the same part of the brain; and if the so-called deep olfactory tract or olfactory bundle of the præcommissura springs, like other fascicles of that commissure, from cortex cells, there seems to be no reason for doubting (what is *a priori* so probable) that the adhesion of the pero to the pes is a comparatively subordinate character. In this case, while there may be more or less fusion and interblending of the two, there

is not a morphological but simply a mechanical connection between them.

3. The ganglion of the olfactory, if the latter be a true sensory nerve, should have chiefly trophic functions. There are several hints that the olfactory nerve is trophic. The fact that the fibres of the fifth or seventh nerve may upon occasion supply the place of the olfactory, if authenticated, might be significant in this connection.

4. The structure of the pero, with its large cells, might also be interpreted in this way. The fact that the fibres lose their sheaths in their passage through the pero, but acquire them at either exit seems favorable to this view.

5. The facts of comparative anatomy seem to us to admit of this interpretation. Of course a more careful and extensive comparison of data especially from embryology is necessary before the view thus tentatively suggested could be seriously advocated.

[It may be added that a somewhat extended study of the olfactory radices in lower vertebrates seems to confirm the above suggestions. In several papers in the Journal of Comparative Neurology, for 1891, the writer has shown the essential distinctness of pero and pes and the tracts related. It is especially evident in fishes where a distinct radix lateralis and mesalis relate the one to the pero the other to the pes, the former ending in the hippocampus, the latter entering the præcommissura.]

Callosum and hippocampal commissure. It is not necessary to recount the various opinions and discussions of the callosum in the marsupials. Until Osborn, most authors had agreed that the callosum is absent and functionally replaced by the anterior commissure. Professor Osborn has done much to place this whole subject in its proper light and we agree with him in respect to the essential homologies of the dorsal commissural system. In one group of fishes the callosum is present, as we have endeavored to prove in several recent papers, and is thoroughly distinct from the anterior commissure. The incomplete development of the cerebrum and especially the suppression of the free cortex causes the callosum to appear greatly displaced and it accordingly lies far cephalad in contiguity with the lamina terminalis in front and fornix body behind. We have too much evidence that structures pertaining to the brain when once acquired are not easily lost to be surprised if the callosum in some form exists in all verte-

brates. In the case of Didelphys the hippocampus and related structures are strongly not to say predominatingly developed. The motor cortex as such is thrown well cephalad and the fornicate gyrus is carried forward along the mesal surface, as may be seen from an inspection of the transverse sections of Plate A. Thus it happens that the caudal portion of the dorsal commissure system is much more highly developed than the cephalic or callosal portion. The later consists of few fibres which spring from the region about the anterior prolongation of the splenial fissure, if this term may be applied to the fissure which bounds the cephalad continuation of the fornicate gyrus. The separation of the callosum and hippocampus commissure must be ascribed in great part to the folding of the hippocampus and its compression by the contact of the thalamus which leaves but one available path—that persued by the fimbriae. It may be supposed that the cephalad point of fixation of the hippocampus is determined by the fornix bundles, which necessarily enter the corpus fornicis at a nearly constant point. That the fibres belonging to the fornix system are distinct from those of a commissural character was suggested by Stieda and seems quite probable from our observations.

The anterior commissure evidently is the chief coordinating commissure of the frontal portion of the cerebrum.

The easiest solution of the problem of the relations of the calloso-hippocampal commissure with the praecommissura would be to homologize the former with the dorsal, the latterwith the ventral commissures of the cord. Yet the anterior commissure receives fibres from almost the entire surface of the cerebrum.

The Praecommissura. Of the three divisions of the anterior commissure which may be recognized, the so called olfactory portion has been sufficiently discussed in connection with the olfactory. The frontal portion is closely associated with it and these two are together less than the temporal branch. The fibres of the praecommissura hug the ventricles and are perforated by bundles from the peduncles.

Dorsad the commissure is bounded by the very large, nearly quadrangular, body of the fornix. Longitudinal sections of the brain at the median fissure show that the two hemispheres are connected by (1) a delicate membranous tela which springs from the cephalo-dorsal tuberosity of the thalamus and passes cephalad to unite with a conspicuous projection of the lamina terminalis cephalad of the hippocampal commissure and dorsad of the anterior commissure. This connection

is not direct along the very mesal line, but here the tela is distended to form a homologue of the dorsal sac of fishes which extend caudad to the epiphysis and is distinct from the aula except along the median line. Its walls give rise to abundant plexus. (2) The hippocampal commissure and fornix body form an oval mass dorsad of the anterior commissure and are attached to it. From the lateral aspects of the fornix body cephalo-ventrad the descending fornix tracts appear. In exactly median sections the fornix body is circumscribed on all sides except ventrad by the ventricle, while the tela springs from a special prominence, but laterad the tela adheres to the fornix body and can be traced to the free margin of the fascia dentata (gyrus uncinatus). (3) The anterior commissure itself is obscurely composed of three portions which are medianly rolled into a compact cylinder. Each has a sheath which can be seen under favorable circumstances. The dorsal and ventral parts are crescentic in section, while the median portion is oval. The dorsal crescent overlaps the ventral cephalad. (4) The lamina terminalis is medianly very thin but contains some gray matter. (5) The callosal fibres are too few to be very obvious in this view.

Dorsal and Ventral regions of the Cerebrum. We think there are good morphological and practical reasons for distinguishing the dorsal and ventral portions of the cerebrum as structures essentially distinct. The limits of the two regions are easily drawn in the opossum. Cephalad the olfactory crus with its cortex is very sharply distinguished from the pre-crucial portion dorsad of it. (Plate A, Fig. 2.) Here the cortex of the ventral portion is very largely covered by the olfactory fibres. Laterad, the two regions are limited, as we proceed caudad, by the rhinalis fissure, mesad the splenial fissure is an equally distinct boundary. Cephalad, these two fissures occupy nearly the same horizontal plane but caudad the former passes ventrad and the latter dorsad, a change which may be ascribed to the interposition of the thalamus. The ventral portion is distinct in cellular structure and presumably in function from the dorsal region. In the former two prominences have their origin, the pyriform lobe of either side caudad. and the post-rhinal lobe cephalad. At the mesal union of the ventral and dorsal regions the hippocampus has its origin as a curious convolution at the splenial fissure. The hippocampus has been carefully described in rodents by C. Judson Herrick in Bulletin Denison Univ. Vol. VI. The relations are still more simple in marsupials and, because

of the absence of the callosum, they may serve as a type for comparison. Beginning at a region cephalad of the union of the two hemispheres (Plate A, Fig. 3.) we observe that the cortex at the splenial fissure becomes very narrow and dense and the cells acquire much the appearance of those of the hippocampus. The outer neuroglia layer is thickened and the peripheral fibre zone is collected in small tracts. These tracts, some of the fibres of which may represent the mesal olfactory tract, are thus described in my notes. "A tract which arises ventro-mesal near the crus of the olfactory (exact locality indeterminate) passes caudo-dorsad within the cortex. The several small bundles emerge into the neuroglia zone and before the formation of a deep splenial fissure have attained a position dorsad to it. Thence they pass caudad and are carried entad by the deepening of the fissure and are last seen in the region of the anterior commissure apparently terminating in cells of the uncinate gyrus."

Entad, a strong tract derived from the cells of this region passes meso-ventrad of the tract mentioned, is separated from the corpus striatum by a spur of the ventricle, and is filled with thickly scattered cells. An oblique band of cells passes from the ventricle ventrad toward the meson and seems a continuation of the irregular chain of cell-clusters characteristic of the pseudo-cortex of the ventral region. On the other side of the ventricle opposite the dorsal end of this cell-series is the cephalic branch of the anterior commissure. The limits of the gyrus fornicatus and uncinatus are more or less arbitrarily determined in mammalia. Ranney considers the posterior margin or splenium of the callosum the point where the former passes into the latter. In the present case, however, there being no such guide, we are forced to depend upon morphological modifications of the organs themselves. The gyrus fornicatus arises cephalad by the fold induced by the splenial fissure already described. It may be traced cephalad nearly to the olfactory. The uncinate gyrus is a second fold which appears as the two hemispheres fuse. (Plate A, Fig. 4.) The free dorsal margin is outwardly folded and at the same time "faulted" by being slid somewhat laterad as if by the agency of the thalamus wedged between the hemispheres. The fornicate and uncinate gyri are curved in opposite senses and related to each other somewhat as are tiles on a roof. In speaking of the uncinate gyrus as the free portion of the median cortex it must be understood in a limited sense, for the mesal margin passes into the plexus and tela and ultimately forms the connection

with the roof of the thalamus. The splenialis fissure grows deeper and curves ventrad, finally curving ventro-mesad (Plate A, Fig. 5.). Meanwhile, the medullary fibres of both the fornicate and uncinate gyrus accumulate to produce the cephalad parts of the fornix. The relations remain nearly the same throughout the posterior parts of the cerebrum though the curvature of the hippocampus about the thalamus causes the transverse sections to fall in other planes. The longitudinal sections of Plate B show that the relations between the two gyri are maintained to the very subiculum.

The cellular structure of the hippocampus bears out the distinctions already made. The cells in both are densely clustered and form practically but a single series. The peripheral processes are from the apices of the elongate fusiform or spuriously pyramidal cells. The entad extremity is frequently almost equally prolonged. The nuclei are large and clear. The cells of the fornicate gyrus are nearly twice as large as those of the uncinate and the latter also lie in a different plane, a fact due to the faulting or rotation of the gyrus as a whole. The structure of the hippocampus and its great complexity in other mammals is due chiefly to the flexture and caudad thrust of the callosum.

For a very complete historical account of the hippocampus and related structures see the works of Honegger [1] while the most recent work on the histology is that by Sala.[2]

After the painful attempt of Honegger to bring into harmony the infinitely diverse nomenclature of this subject we can but feel that a strict morphological terminology best meets the case. Embryology and comparative anatomy leave no doubt that we are dealing with two folds of the caudo-mesal cortex which are simply plicated and then curved upon each other. One margin of the structure is connected directly with the occipital cortex, the other with the tela and proplexus. The mesal convolution is the fascia dentata or gyrus uncinatus produced, the lateral convolution is the gyrus fornicatus. The alveus is the ental fibre zone of the gyrus fornicatus and the fimbria is the transition of the alveus into the fornix and hippocampal commissure.

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[1] J. Honegger. Vergleichend-anatomische Untersuchung ueber den Fornix und die zu ihm in beziehung gebrachten Gebilde im Gehirn des Menschen und der Sangethiere. Genf. 1890.

[2] L. Sala. Zur feineren Anatomie des grossen Seepferdefusses. *Zeitschrift fue wissenschaftliche Zoologie.* LII. I. 1891.

That portion of the cortex within the gyrus fornicatus is the stratum griseum circumvoluta of authors. The ectal tract of this convolution is the so-called lamina nuclearis. Meynert, with his usual morphological insight, recognized in the fascia dentata the free margin of the mesal portion of the manth. These relations are especially well seen in Plate XVII. of Honegger's work. As Sala says, the sole difference between these gyri and other parts of the mantle consists in the fact that the cells are crowded into a single narrow layer. With the statements of Sala respecting the histological relations we are unable at present to agree. 1st. That author describes the cells of the fascia dentata (gyrus uncinatus) as splenial. We think that, when the cell body is preserved, it differs from those of the gyrus fornicatus chiefly in size, but it lies in a different plane. We are furthermore unable to discover how the distinction between the protoplasmic and nerve process is made out in cases where they are so similar. 2d. Sala states that the large cells of the gyrus fornicatus are functionally connected with the fibres of the alveus, while the apical processes subdivide interminably and terminate in the processes of neuroglia cells. The nervous processes may spring from either end of the cells and either pass directly entad to the alveus or ectad to the fibre layer immediately adjacent and then return to the alveus. If the evidence of our sections is to be trusted, the apical fibres pass directly into the ectal tract while the opposite extremity of the cell subdivides dichotomously, producing such a neuropilem as Sala himself figures, with which the alveus fibres may communicate.

It seems scarcely to be doubted from the course of the radix lateralis that its fibres reach the surface of the hippocampus and connect either directly or indirectly with the ectal layer of this region. The great mass of the alveus fibres are derived from the ental aspect of the fascia dentata. Thus, according to our view, the lamina nuclearis and superficial bundle of the fascia dentata are parts of the tract from the radix lateralis. Strong confirmation of this suggestion is found in the much simpler relations in fishes. (See forthcoming paper in Journal of Comparative Neurology for December.)

The Cerebral Cortex.

The cortex of the precrucial lobe may be regarded as typically motor, but even here there are many cells of the ectal series which divide at once into two or more strong processes and these in turn again divide dicotomously until a dense felting of fibres develops over

the ectal layer. Into this felting pass the apical fibres of the pyramids of the smaller size or ectal series. It is not easy to trace the ultimate course of these fibres, but in some cases, at least, they obviously divide into two and are lost in the neuropilem above referred to. Beneath the small pyramids at a variable distance is an ill-defined layer of larger pyramids whose apical processes seem also to pass into the neuropilem. Still entad of the giant pyramids are the usual multipolar cells adjacent to the white mater or fibre zone. More or less frequent in all of these layers, but especially entad, are large clear granular nuclei surrounded by unstained spaces which may represent the bodies of unstained cells of the aesthesodic type. In cases where the cell-body is stained it almost invariably has the apical process directed entad. The average length of the body of the small pyramids is about .03 min., while the giant pyramids are more than .04 min. exclusive of processes.

The cortex of the crus, i. e. of the lateral aspects of the cerebrum below the rhinalis fissure is the same as that of the ventral part of the cortex farther caudad.

Longitudinal perpendicular sections exhibit little difference between the cephalic and caudal portions of the dorsal cortex although the latter portion seems to possess proportionally more of the second type of cells.

In a section of the parietal region the neuroglia layer consists of an outer less densely stained layer and an ental layer which latter is suffused with stained matter evidently of an albumenous character. The inner layer may be called the ectal neuropilem zone because of its being filled with the finely dividing process of layers within. The anastamosis of these fibres, while very probable, has not been observed.

The cellular elements in this layer are inoblasts of connective fibres and Deiter's cells. Beneath the neuroglia is a band of cells forming the ectal portion of the cell-bearing cortex. The cells are small pyramids in part but a careful study shows that there are many cells of a somewhat different character, i. e. the peripheral process is not simple but branches dichotomously and then subdivides into a fine fibrilary felt. Immediately above and about this layer the felting of fibres is most dense and results frequently in a diffuse coloration rendering observation difficult. Beneath this layer there follow successive layers of small pyramids with some fusiform cells. The fibres from the apex in each case is continued to the ectal neuropilem zone there

dividing to mingle with the previously described fibres. The basi-lateral processes (there are no axial basal processes in the sense implied by Meynert) subdivide and form a diffuse mesh-work or felting which is nowhere concentrated to form a definite zone. Although it cannot be considered certain, it nevertheless seems probable from the appearance of the sections that these processes become associated indirectly with the cells next to be described.

The median and deeper parts of the cortex are everywhere, except in a few isolated motor nests, sprinkled with cells of a very different appearance. The cell-body scarcely stains with mercuric hem atoxylin but the nucleus is brought out distinctly without being rendered opaque. The latter is large, often quite as large as the diameter of the smaller pyramidal cells. The contents of the nucleus are granular. The area about the nucleus may be vacuolate or the somewhat shrunken fusiform or irregular cell body may be sufficiently stained to be detected with care.

In a great many cases it is possible to trace the basilateral processes of the large pyramids to the immediate vicinity of these cells where they seem to form a loose reticulum.

The pyramids almost uniformly have near their bases one or more small dark nuclei such as we have called Deiter's bodies. The regions of the cortex near the white fibre zones are filled with multipolar cells with several basal and one peripheral process as the rule.

Histology of the ventral part of cerebrum. Fig. 1, Plate B illustrates the appearance of a horizontal section taken ventrad of the union of thalamus and hemisphere. Three distinct portions are presented; cephalad the large olfactory lobe with quadrangular outline and large ventricle. The pero is evidently separated from the pes by a ganglionic layer. The lobe obliquely applied to its crus so that the median surface extends much farther caudad than the lateral. The radix lateralis appears as a thick tract passing directly caudad to the pyriform lobe. The crura are long and connect with the ventro-median projections which we have called post-rhinal (or ventro-median) lobe. (The olfactory region is described in detail above.

The post-rhinal lobe is largely covered superficially by olfactory fibres. Entad to this are irregular clustres of cells and dense aggregates of Deiter corpuscles in opaque patches of neuroglia. The cells are of the type which we have termed rhino-morphic, i. e. are small irregular pyramids. Fig. 10, Plate A illustrates such cells upon the

confines of a clustre of Deiter cells. Within the cortex there are irregularly disposed sensory cells. It will be observed that the post-rhinal lobe lies in or near the anterior perforated area. Comparing the mammal brain with that of Sauropsida, it seems legitimate to conclude that these sharply localized clustres of corpuscles correspond to the proliferating areas of the axial lobe of the reptiles and birds. The presence of great numbers of vessels is essential for this purpose. The opaque color of the region in which the corpuscles are imbeded may be accounted for by the supposition that albumenous matter is collected about the proliferating centres. May it not be that those cells which are so uniformly associated with the large end of the pyramid cells of the cortex are derived from this or some similar source? In this case, we have a novel modification of phagocytosis in the brain.

In the caudad portion of the post rhinal lobe, especially ventrad, the cell clustres and granular areas are especially numerous. The third portion of the section consists of the pyriform lobe, which at this level is similar in outline and size to the olfactory. The laterad, caudad and mesad are provided with a strong sub superficial zone of cells to be described more at length beyond but there is also a considerable admixture ventrad and mesad of the rhino-morphic cell type. In the central part of the pyriform lobe are numerous clustres of Deiter cells within clear spaces of the neuroglia, reminding one of those clustres or rosette-groups of cells found in similar regions of birds and reptiles.

The cortex of the regions ventrad of the rhinalis fissure has a habitus of its own. Immediately beneath the neuroglia layer the cortex is densely massed with only sparse pyramidal cells scattered entad without the stratification encountered in the dorsal cortex. The cells of the superior dense layer vary astonishingly in form, some being regular pyramids while the greater number are multipolar with numerous processes which pass into the neuroglia zone and there break up into a fine reticulum or felting of fibres which cannot in these sections be seen to anastomose or to enter the superficial tracts (radices of olfactory or otherwise). The deeper cells are chiefly pyramids and are frequently so isolated as to appear beautifully distinct. (Fig. 7, Plate C.) The apical process is generally peripheral and can be traced into the neuroglia zone where it can be seen in many cases to break up into numerous fine branches. The cell body is elongate pyramidal with numerous lateral and basilateral branches which subdivide and weave

themselves into the reticulum in which they lie. In only a few cases have actual anastomes been observed. The nuclei are large and elongate and there is a marked tendency for small corpuscles to associate themselves about the base between the spreading branches of these cells.

In some cases, especially toward the ental fibre layer the pyramids are reversed and the apex process passès centrad. Near the contact with the white matter the cells are rather multipolar than pyramidal and their chief process appears to pass into these fibre tracts. The white fibre layers at the surface in this region seem to be derived from the radix lateralis of the olfactory. Longitudinal sections seemed to indicate that the lateral radix divides or other fibres become associated with it, at least a band of obliquely-cut fibres may be seen ectad to those are passing directly caudad. The latter portion is thought to pass obliquely over the median surface to the hippocampus while the ectal portion seems to spread out in diminishing quantity upon this region The vast quantity of fibres overspreading this region (i. e. lateral and ventral part of pyriform lobe) seems to preclude the possibility of all having been derived from the radix lateralis. The ventral regions of the pyriform exhibit pyramids mingled with large multipolar or fusiform cells with large clear circular nuclei. In some cases it seemed probable that the axial processes of the pyramids first described suddenly turn as they reach the neuroglia layer. In other cases and in the case of the superficial multipolar cells the is no doubt that the processes subdivide very minutely. This region of the neuroglia is so filled with non-medulated fibres as to stain more deeply than other regions. We seem here to have a neuropilem in the sense suggested by Koelliker.

In the infra-rhinal type of cortex strands of fibres may often be seen passing from the ectal nervous reticulum between the cells toward the central white matter. This is especially apparent at the caudal extremity of the pyriform lobe.

Cortex of Occipital region. In the lateral aspect of the occipital region dorsad of the rhinalis fissure we encounter a commingling of two distinct kinds of cells. The pyramidal cells are present over most of the cortex, being most numerous peripherally. They can be recognized by the deeply stained elongate nucleus and form of the cell. The second class consists of cells of a fusiform or pyriform (i. e. flask) shape. With the selective stains used, haematoxylin and Hg Cl_2, the

nucleus alone stains in most instances and this not deeply. A reticulum within the clear nucleus is brought out, but, as a rule, no distinct nucleolus. Where the cell contour is visible it is as described above. Such cells are associated with the deeply stained pyramids in such a way as preclude the view that the difference could be duc to varying treatment.

The distinction once relied on by us, i. e. the direction persued by the apical process does not seem constant here. The deeper cells have the apical process directed entad while the ectal series may have the reverse position. The dorsal portion of the occipital region is occupied by these flask cells almost to the exclusion of all others. In longitudinal section at the poserior part of the cortex the following observations were made. There are here few pyramidal cells and a relatively large number of pale cells which contain large clear nucleoli and chromatin (?) mesh-work. The cell body is frequently so inconspicuous as to make the nuclei appear like free corpuscles. In many cases sufficient care will detect the cell outlines and in other spaces in the neuroglia testify of their presence. The outline of the cell is rarely as distinctly pyramidal as in the motor type through peripheral processes in some cases at least pass dorsad. See plate C, Fig. 6, which is a drawing of a portion of the occipital region (IV—7.) as seen with the one-fifth inch objective. *m.* is one of the pyramids and *s.* one of the supposed sensory cells. The almost constant presence of Deiter's cells at the base of the pyramids will be noticed. This region may be contrasted wit a typical motor area as drawn in Fig, 1 of the same plate or Fig. 2. A mixed area some distance beneath the ectal layer of cortex is drawn in Fig. 11, Plate A. In this case the sensory cells are almost unstained except the nucleus. (4—14.) In even the typical motor regions these pale cells are always present though in less numbers and mostly crowded to lower levels. Toward the posterior part of the hemispheres the cortex along the middle of the lateral aspect differs quite obviously from any other portions. The band is rather narrow and consists of small and slender cells which are in many cases pure fusiform elements, others are flask-cells, or rather inverted pyramids, but careful examination with one fifteenth inch objective (1500 diameters) shows that the process directed proximally does not form a single axis cylinder, as appears at first, but dissolves into several small fibres. Among these cells are a few with the usual pyramidal structure, but more slender than usual. Near the white

matter are large cells which change their direction to correspond with the direction of the tracts. This lateral area may have other functions than the dorsal or ventral area, but what the functions difference may be it is impossible to conjecture.

The motor regions of the cortex are illustrated by Figs. 1 and 2, of Plate C. Fig. 1 is a drawing made to a scale illustrating a strip of cortex extending from beneath the giant cells nearly to the upper cell layer. The region is in the fronto-dorsal cortex near the median fissure. The two drawings are part of the same strip of cortex, the right end of No. 1 being near the dorsal surface. The forms vary considerably, some of the cells being simply fusiform, others inverted pyramids while there are a few æsthesodic cells among them.

Fig. 2, is a camera drawing of the cortex from the deep pyramids to near the ectal layer. The apex processes extend beyond the cortex. The process of nutrition of the pyramids suggested elsewhere is well seen here. Several of the carrying corpuscles are often seen at the base of one pyramid. Fig. 4, Plate C, is a camera drawing of a few of the deep pyramids or giant cells under the one-fifteenth objective.

The general conclusions growing out of this investigation are briefly as follows: There is in the opossum a decided difference between the aesthesodic and kinesodic cell types. Regions known to be sensory contain a large number of the type with clear round nuclei. The delimitation of the areas is, however, very incomplete. This agrees well with the results of experiments. The two classes of cells are rarely unmixed in any area. In many cases at least the cortex cells give off processes which divide in the so-called neuroglia layer to form either a neuropilem or reticulum. It would seem that a more or less connected reticulum of fibres directly supplied by the cells is the simplest anatomical device which can in any way be associated with unit states of consciousness.

The probem of nutrition of the specific nerve cells is, we believe, somewhat simplified by the suggestion that there are special proliferating centres in the brain base in which there are produced numerous corpuscles like Deiter's cells which then migrate to the cortex and convey nutriment to the cells. The small and frequently shrunken bodies at the bases of pyramidal cells are interpreted as such nutrient bodies from the sources indicated, one of which is the post-rhinal lobe near the substantia perforata anterior. With reference to the fact that

the cells regarded as kinesodic generally have their apical processes directed peripherad (the converse being the case with the æsthesodic,) it must be said that too much confidence should not be placed in this distinction. We now believe that the direction of the apical process is to be interpreted as a function of the direction from which the cell has migrated. We have shown in a series of papers that there is morphological and embryological evidence that the cortical cells are not formed in situ but have migrated from proliferating areas primarily found in the axial lobe. This suggestion has recently been greatly emphasized by the discovery that the axial lobe of fishes contains well marked areas of the two kinds of cells sustaining the proper relations to the tracts to enable us to identify them as motor and sensory respectively. It is believed that the motor areas of the cortex are supplied by cells which migrate from before backward and first lodge in the cortex, whence many subsequently migrate to deeper zones. Such migrating cells retain their connection with the peripheral source by means of the long apical processes. Sensory cells, having in many cases a different path of migration, naturally occupy different positions. In view of the recent results of Golge's method of staining, it would be premature to decide how far these processes are simply nutritive and how far actually nervous. It is significant, however, that the processes of nutrition apparently go on at the base of the cell as indicated by the nutritive nuclei there collected.

PLATE A.

A series of transverse sections through the cerebrum of the opossum.

Fig. 1. Section through the olfactory lobes.

Fig. 2. Section at the junction of the crus and post-rhinal lobe near the union of the rhinalic and splenial fissures.

Fig. 3. Section through the fore part of the cerebrum.

Fig. 4. Section through the anterior commissure and fornix body.

Fig. 5. Section at the caudal part of the anterior commissure, showing the encroachment of the radix lateralis mesad and the dorsal sac

Fig. 6. Section through the præthalamus and chiasm

Fig. 7. Section through the mesencephalon at the posterior commissure and hippocampus.

Fig. 8. Section through the occipital portion of the cortex and nates.

Fig. 9. Section through the cerebellum and pons.

Fig. 10. Portion of area of the post-rhinal lobe [region of Fig 3a,) embracing a portion of one of the granular masses as well as of the rhinomorphic cells.

Fig. 11. Portion of a section of the dorsal cortex near the meson. The figure embraces a region near the surface and shows two kinds of cells. The apex processes of the motor pyramids are very long, extending to near the upper level of the cortex, while the cells of the second type have the cell body almost unstained.

Fig. 12. Cortex of the mesal surface near its ventral limit. The mesal olfactory tracts are here breaking through the cortex. The position of the cells is disturbed and the apical processes dip out of the section. The surface is at the right.

PLATE B.

A series of eight horizontal sections through the entire brain beginning ventral and passing cephalad of the anterior commissure.

Fig. 8. A horizontal section through the superior commissure.

PLATE C.

Fig. 1. Portion of the cortex from the dorsal surface near the median fissure, extending as far entad as the giant pyramids. (Slide 28.) The cells are chiefly motor pyramids.

Fig. 2. Large pyramids of the parietal region, from a horizontal section. Camera drawing with one fifth inch objective.

Fig. 3. Ectad pyramid cells from præcrucial lobe near the median line. Camera drawing with one-inch objective.

Fig. 4. A few pyramid cells from the dorsal cortex drawn with one-fifteenth inch objective and camera. Observe the nutrient cells at the base in each case.

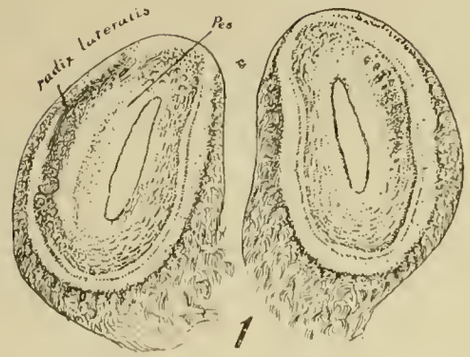
Fig. 5. Typical sensory cells from near the base of the cerebrum.

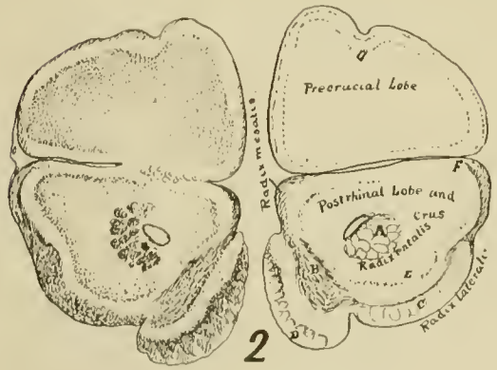
Fig. 6. Portion of the occipital cortex showing the two kinds of cells.

Fig. 7. Portions of the lateral cortex ventrad of the rhinalis fissure and beneath the olfactory fibre zone. The neuropilem above lies just entad of the radix laterals tract.

Fig. 8. Cells from the hippocampus at Fig. 5a, Plate A, showing the relations of the processes of the cells of the gyrus fornicatus to the ectal tract.

ERRATUM.—Page 86, line 11, for *splenial* read *spherical.*


radix lateralis
Pes
1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Postrhinal Lobe and Crus
Radix entalis
Radix lateralis
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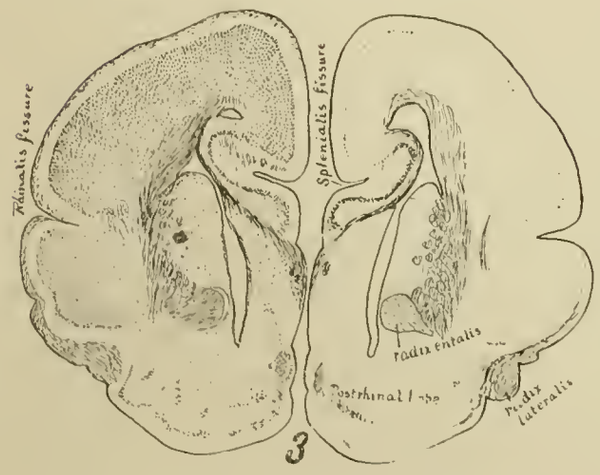
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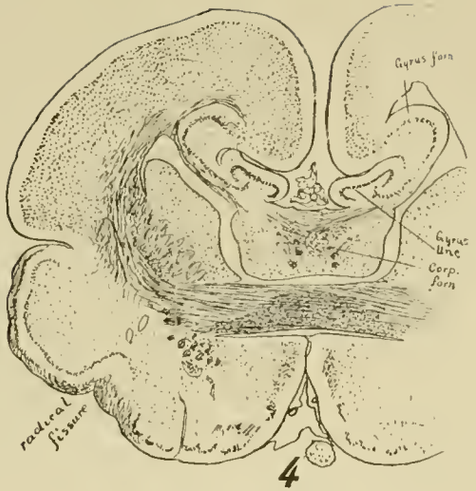
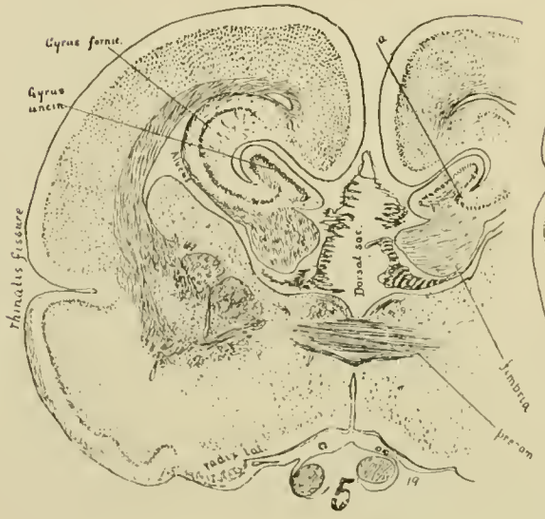
Splenialis fissure
Radix entalis
Postrhinal Lobe
Radix lateralis
3

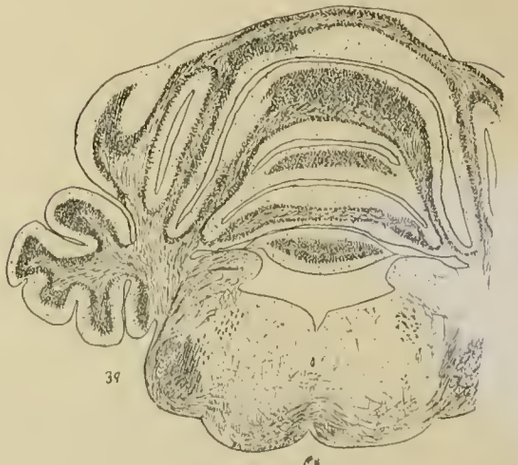

Gyrus forn
Gyrus unc
Corp. forn
radical fissure
4


Gyrus fornic.
Gyrus uncin.
Rhinalis fissure
Dorsal sac.
fimbria
radix lat.
5

6

7

8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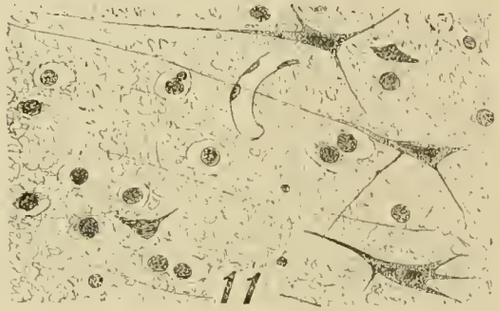
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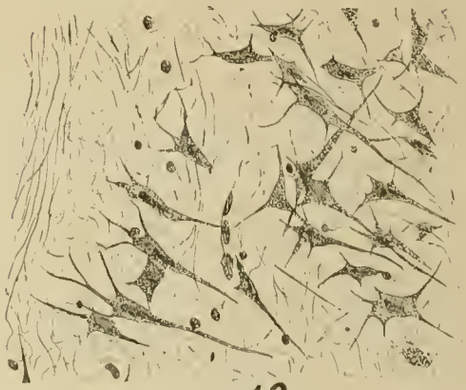
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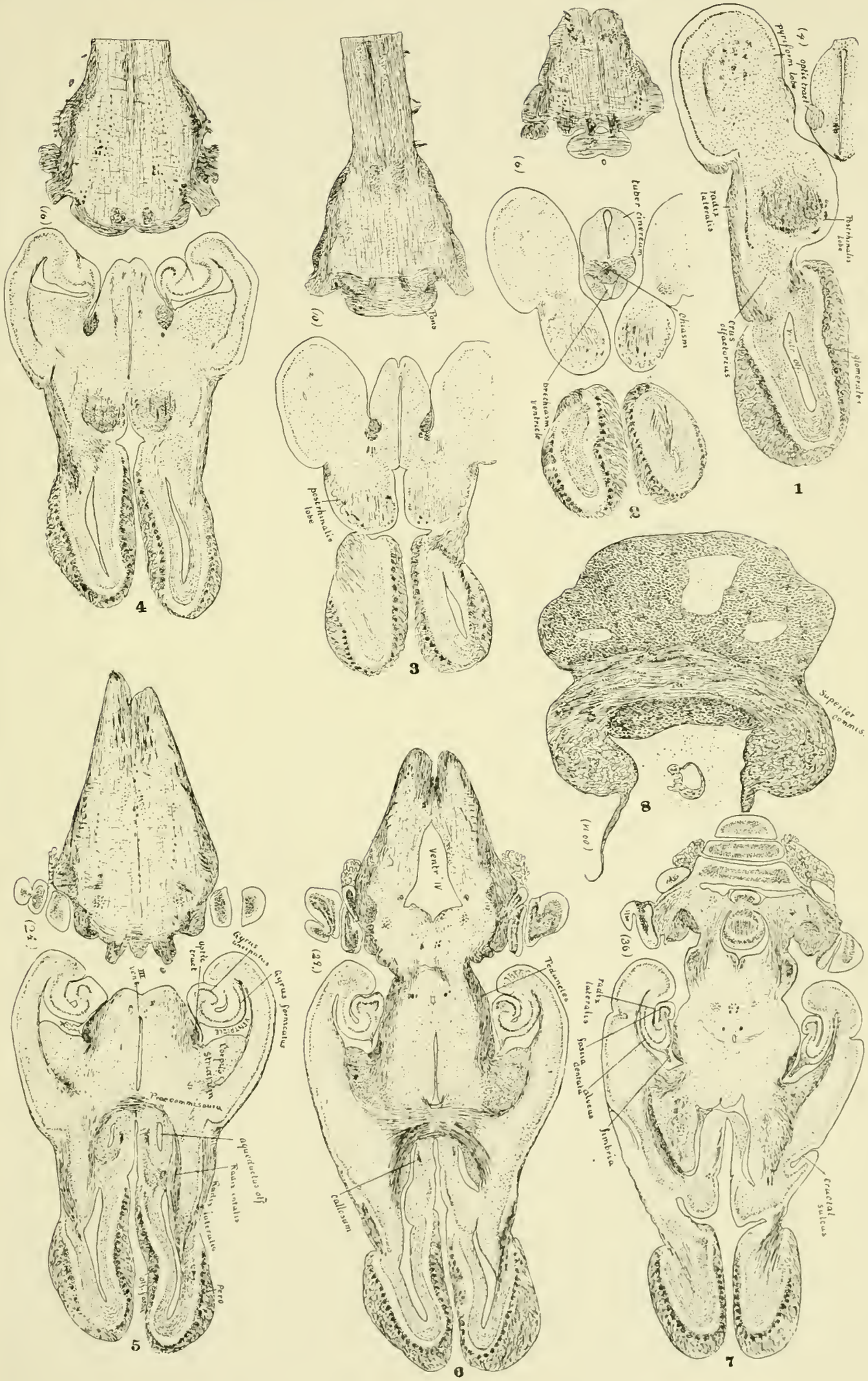
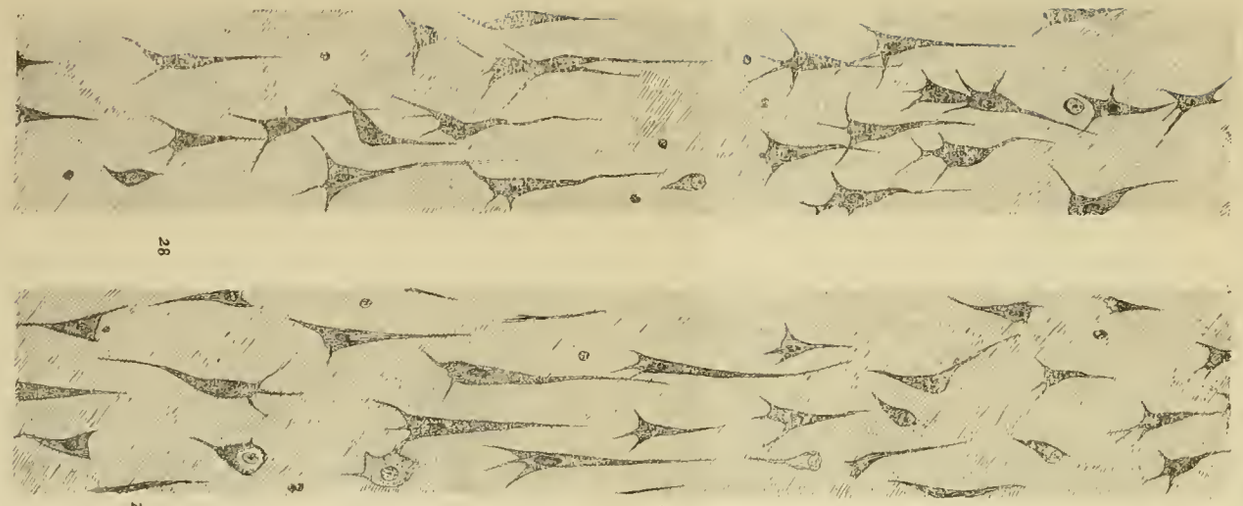

(4)
Pars optica hypothal.
optic tract
Postinfundibular lobe
Postinfundibular lobe
Pedunculi laterales
Pedunculi laterales
Crus cerebri
Crus cerebri
Ventricle
Ventricle
Glomerulus
1
(6)
Tuber cinereum
Chiasm
Infundibulum
Infundibulum
Infundibular ventricle
2
(9)
Pons
Pons
3
(6)
4
(24)
Gyrus uncinatus
Gyrus uncinatus
Optic tract
Optic tract
III ventricle
III ventricle
Gyrus fornicatus
Gyrus fornicatus
Corpus Striatum
Corpus Striatum
Precommissura
Precommissura
Aquaeductus cerebri
Aquaeductus cerebri
Pedunculi cerebri
Pedunculi cerebri
Pedunculi laterales
Pedunculi laterales
Pons
Pons
5
(29)
Ventr. IV
Ventr. IV
Pedunculi
Pedunculi
Callosum
Callosum
6
(36)
Pedunculi laterales
Pedunculi laterales
Fossa centralis
Fossa centralis
Fimbria
Fimbria
Cruciate sulcus
Cruciate sulcus
7
(10)
Superior commis.
Superior commis.
8



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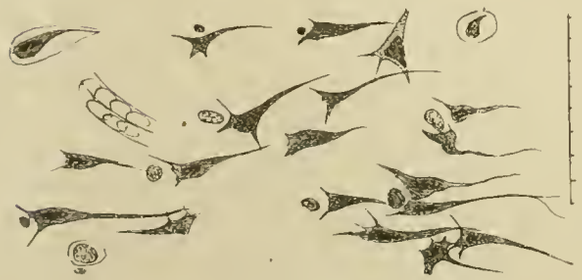

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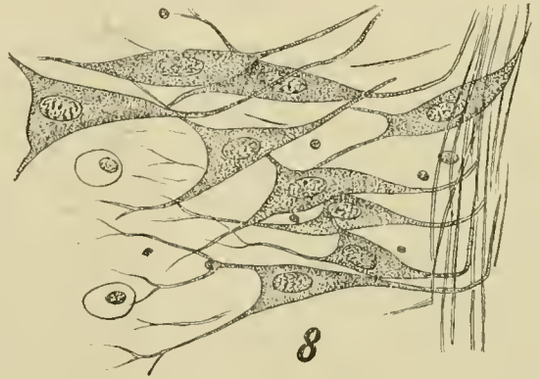

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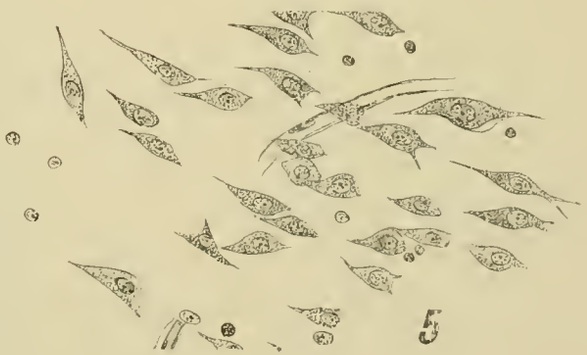

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3 2044 106 255

Date Due

19 May '49
19 May '49